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Cost-Oriented QC and Process-Oriented QC; Which is more Desirable Approach?

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ABSTRACT

This paper introduces two approaches of the cost-oriented QC and the process-oriented QC, and compares them on several aspects.

The cost-oriented QC tries to assure the specified quality level by sampling inspection within minimum quality cost, while the process-oriented QC aims at realization of target value of quality specification through process adjustment when a product deviates from the target.

But the final purpose of both approaches is on quality assurance for markets and consumers.

After all, desirability is a question of quality cost. This paper suggests two of cost functions for decision making criterion.

1. Introduction

No one can deny that quality and productivity improvement are vital to successful operation. Quality is an indispensable factor for productivity, and it contributes directly and indirectly to productivity enhancement (1).

Many different methods and techniques have been employed in quality control. And the basic philosophy and attitude of quality control is categorized into two; one is cost-oriented QC and the other is process-oriented. The cost-oriented QC includes economic selection of quality level, optimal sampling plans, and interrelated sampling plans (2).
Taguchi (3) emphasized the process-oriented quality control, and criticized the cost-oriented quality control in his paper. This paper introduces the basic concept of the two approaches, and suggests two of cost functions as a criterion to discriminate which is more desirable approach.

2. Cost-oriented Quality Control

The cost-oriented QC is a synonym of the economics of QC. Its basic concept is to assure a specified

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quality level within minimizing costs related to quality.

The economics of quality control and/or manufacturing system is divided into three basic areas, namely,

. economic selection of quality level
. economic or optimal sampling plans
. interrelated sampling plans

2.1. Economic Selection of Quality Level

The basis for economic analysis of the alternatives is similar to other forms for evaluation of economic performances. The most familiar is the economic concept of break-even point (BEP). This concept of BEP is inherent to the construction of Stoner's Profitgraph, and is adapted specifically to techniques for the analysis of inspection economics by Feigenbaum. The equivalent form is defined in terms of an economic quality level, or EQL, a threshold for decisions which concern quality performance. Mottley (4) illustrates the technique for effective economic analysis of inspections using indifference quality levels, IQL. IQL is the point of control between the lot quality willing to be accepted all the time and the lot quality willing to be rejected all the time (5).

2.2. Optimal Sampling Plans

Acceptance sampling plan consists of sample size and decision making criterion whether a submitted lot is accepted or rejected. For any given lot, the sharpness of decision is a function of the sample size. The greater sample size becomes, the more it costs for sampling and inspection. Thus, the optimal sampling plan should be determined considering to sharpeness of decision and cost for any types of sampling.

2.3. Interrelated Sampling Plans

By understanding a manufacturing process from receiving raw material to shipping finished goods to the markets or consumers as a serial system, it tries to find suboptimum inspection plan for each stage in order to keep global optimum within assuring the final quality level specified.

Even though a manufacturing process constructed in complex, it can be easily extended by branch- compression technique to a simplified system of manufacturing and inspection stages, as shown in Fig. 1.

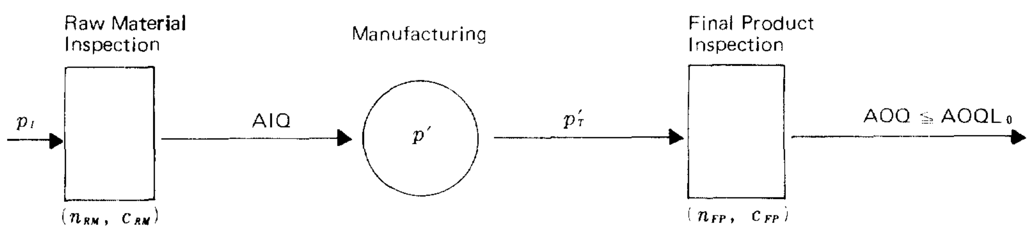

Fig. 1. Illustration of Simplified Manufacturing Process and Transition of Quality Level for Each Stage.

For the system of Fig 1, a lot of N units enters the system with an average incoming quality to the system of p_I. The material is submitted by single sampling inspection with replacement, and produced an average incoming quality of the manufacturing stage, AIQ. The manufacturing produces the fraction defective, p'. The fraction of defective units before final product inspection and after the manufacturing process is p'_T. The value of p'_T is a combination of p' and AIQ, and as p' and AIQ are not mutually exclusive,

$$p'_T = p' + AIQ - p'^{*}AIQ \quad \cdots\cdots\cdots\cdots\cdots (1)$$

It is not so difficult to build a model from Fig. 1. The decision variables are p_I, n_{RM}, c_{RM}, p', n_{FP}, and c_{FP} The objective is to minimize the total expected manufacturing cost subject to the final product sampling plan for assuring the specified AOQL, $AOQL_0$.
A dynamic programming model and its solution technique is illustrated by Subramanian, Hassen and Knowles (2), Garcia-Diaz, et al. (6).

3. Process-oriented Quality Control

Each product has its quality specification as a target which is designated at the product design stage. It is very important to keep the deviation of the product within permissible limits from process design to its control before acceptance sampling. The above mentioned, so far, is the main idea of the process-oriented quality control. Taguchi has advocated the merits of on-line quality control in Japan, and contrasted with the cost-emphasized quality control in U.S.A. and Europe.

3.1. Quality Loss

It is obvious that the loss is caused whenever quality characteristic value deviates from the target regardless of the magnitude of deviation. And it is possible to convert the magnitude of deviation into the cost function mathematically.
If, let the loss be denoted by $L(y)$, it can be described as follows;

$$L_{(y)} = \frac{A}{\triangle^2}(y-m)^2 \quad \cdots\cdots\cdots\cdots\cdots\cdots\cdots (2)$$

And the average value of loss is;

$$L = \frac{A}{\triangle^2} \cdot \sigma^2 \quad \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots (3)$$

where, A : cost per defective
$\triangle$: tolerance
σ^2: mean of variation

3.2. Total Cost Function

The total loss function, including the process control cost and the penalty cost due to variability, is given by the following equation.

$$L_{(T)} = \frac{B}{n} + \frac{C}{U} + \frac{A}{\triangle^2}\left(\frac{D^2}{3} + \frac{n/2+\ell}{u} \cdot D^2\right) \quad \cdots\cdots\cdots\cdots\cdots (4)$$

$$U = \frac{D^2}{D_0^2} \cdot U_0 \quad \cdots\cdots\cdots\cdots\cdots\cdots (5)$$

$$n = \sqrt{\frac{2U_0 B}{A \cdot D_0^2}} \cdot \triangle \quad \cdots\cdots\cdots\cdots (6)$$

$$D = \left\{ \frac{3C}{A} \times \frac{D_0^2}{U_0} \times \triangle^2 \right\}^{\frac{1}{4}} \quad \cdots\cdots (7)$$

where; A : Loss of a defective
B : Measuring cost
C : Adjusting cost
n_0 : Current measuring interval (units)
u_0 : Current average adjusting interval (units)
D_0 : Current control (adjusting) limit
ℓ : Time lag of measurement (units)
n : Optimum measuring interval (units)
D : Optimum control limit
U : Forecasted average adjusting interval (units)

In equation (4), the first two terms become the process control cost which are consisted of measuring cost and adjusting cost, respectively. And the third term represents penalty cost which occurs due to variability of product. Mathematical procedure around equations is eliminated in this paper (Further reading: Ref. (1)).

4. Comparison and Analysis of Two Approaches

This paper, so far, briefly introduced the basic concepts of the cost-oriented QC and the process-oriented QC. Exhibit 1. summarizes the differences between two approaches.

Exhibit 1. Comparison of The Cost-oriented Q.C. and The Process-oriented Q.C.

View Point	Cost-oriented Q.C.	Process-oriented Q.C.
Main idea	. Minimize total cost deduction of fraction defective	. minimize deviation of product . produce the products in a way
Optimization	. cost emphasis	. quality emphasis
Variation index	. fraction defective . defect	. process capability . loss function
Quality evaluating measure	. fraction defective · defect	. signal to noise
Q.C. key activities	. product inspection . design review	. product design . process design . process control
Inspection stage and number	. along to the structure of process	. along to process variation
Prevails	. U.S.A., Europe	. Japan

But this paper would not agree with Taguchi's on some aspects. The first to say is the relationship between quality and cost. Quality and cost interacts with each other. In other words, cost is a function of quality level. Quality, regardless of cost, itself can not be a measure to be compared with. Thus, it is able to be compared the superiority and/or inferiority with two approaches when the performance of process-oriented quality control is transformed into monetary units, as Taguchi did.

The second consideration is on the economic environment. It is desirable to develope a suitable QC method in accordance with the economical environment whether the country has abundant resources or not. Thus, the cost-oriented QC in U.S.A. and Europe and the process-oriented QC in Japan are rather a philosophy than a methodology of QC. There could not be any superiority and/or inferiority but just difference on philosophy.

Finally, when the process has been equipped full automation system and operated under the stable status, the cost-oriented QC costs less than the other does. However, it is needed to consider which is more suitable approach. There is nothing besides cost as a criterion of decision making. In cost-oriented quality control, the expected cost directly related to quality is sum of the inspection cost and penalty cost.

$$T_c = \sum I_c + P_c \quad \cdots\cdots\cdots\cdots\cdots\cdots (8)$$

where,
T_c : total cost of cost-oriented QC
$\sum I_c$: sum of raw material, in process, and final inspection cost
P_c : penalty cost due to defective

While, in process-oriented quality control, process adjusting cost will be added. Then,

$$T_p = \sum I_p + A_d + P_p \quad \cdots\cdots\cdots\cdots (9)$$

where,
T_p : total cost of process-oriented quality control
$\sum I_p$: sum of raw material, measuring in process of the deviation of product, final inspection cost
A_d : adjusting cost of process
P_p : penalty cost due to defective

Simply to say, when T_c is smaller than T_p, the cost-oriented approach is more profitable, or not the process-oriented is desirable.

5. Conclusion

The cost-oriented quality control tries to assure the specified quality level through sampling inspection with minimization of cost, while the process-oriented aims at realization of target value of quality specification through process adjustment when a product deviates from the target. But the final purpose of both is on quality assurance for markets and consumers. It might be a little bit faulty expression, because quality control is a basic philosophy and an attitude rather than just an elaborate system. Anyway, that the process-oriented quality control is profitable when T_p is smaller than T_c in equation (8) and (9), respectively, if not, vice versa. Generally speaking, in case of high-priced products, ordering production system, and/or incursion of serious penalty cost effects, the process-oriented approach would be suitable, while the cost-oriented approach is suitable for automation systems in mass production industries.

國 文 要 約

本 研究에서는 品質管理의 推進을 費用 指向的인 方法과 工程指向的인 方法으로 大別하고 各各의 特徵을 說明함과 아울러 比較分析 하였다. 또 現場 Q. C擔當技術者들이 品質管理를 實施함에 있어서 方向을 모색한다거나 現在 實施하고 있는 方法의 妥當性을 체크하기 위한 基準을 費用函數로서 提示하였다.

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