

# Quality Engineering with Taguchi Loss Function Method and Improvement of Work Method in Anode Changing

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**Abstract.** One of the companies engaged in aluminum smelting production has problems, namely the occurrence of high variations in the removal of new anodes to the old anodes which are influenced by the operator's working method because of unnecessary movements and movements beyond the Anode Changing mechanism set by the company has become a habit of the operator itself, so the time needed to replace the anode is getting longer. This problem causes the company to suffer losses due to the production process that runs not in accordance with established procedures. So, the company needs to calculate the losses incurred due to variations in anode replacement and see how the operator's working method when changing the anode that causes these variations and also has an influence on the anode replacement cycle time. The method used for this problem is Taguchi Loss Function which is used to calculate the losses suffered by the company and improve work methods using the Modular Arrangement of Predetermined Time Standards (MODAPTS) method to calculate the processing time. The results obtained using this method are losses experienced by the company in Block 1 amounting to Rp 19,733,263, while the total losses in Block 2 amount to Rp 35,919,435. While for the operator's working method, the operator's work movements are analyzed which are not in accordance with the economic principles of the movement. Comparison of the standard time of actual and proposed work methods is 774.847 seconds and 648.2 seconds with a time difference of 126,647 seconds faster and there are no movements that should not be done so that the operator can use the time to adjust the anode height as well as possible according to the standards determined by the company.

## 1 Introduction

The design of the production process is one part of quality engineering activities. Production processes that pay attention to quality will produce good quality processes so that they can avoid losses in production costs, processing time and others. Quality control is an activity to ascertain whether the policy in terms of quality (standard) can be reflected in the final result, or in other words an effort to maintain the quality or quality of the goods produced to conform to the product specifications determined based on the leadership policy [1,2]. The smooth production process is strongly influenced by the production system that has been prepared before the company carries out the production process. In addition, for the sake of the smooth production process, it is also necessary to control the production process which will control all important components in a company [3]. The production process to produce a kind of output is difficult to avoid the occurrence of variations in the process of defining variation as a tendency in the production or

operational system so that the difference in quality at the output (goods and services produced) [4,5]. To solve these problems, this study will use the Taguchi Loss Function method. Taguchi has the view that quality is related to costs and losses in the monetary unit. Losses suffered include the production process and losses suffered by consumers [6,7]. Quality is anything that can satisfy customer desires or according to customer requirements and requirements [8]. The purpose of the Taguchi loss function (loss function) is to evaluate quality losses quantitatively due to variations [9]. In analyzing and evaluating work methods to obtain a more efficient working method, it is necessary to consider the economic principles of the movement. The economic principle of this movement can be used to analyze local work movements that occur in a work process and also for work activities that take place comprehensively from one process to another [10].

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This method is widely used in research, one of which is research conducted by Antony Jiju (2001) regarding Simultaneous Optimization of Multiple Quality Characteristics in Manufacturing Processes Using Taguchi's Quality Loss Function. The methodology uses the Taguchi's quality loss function for interaction effects and also for determining the optimal condition of the process. In order to demonstrate the proposed methodology, a simple case carried out for optimizing three quality characteristics, namely solder paste mass, solder paste height, and glue torque, for a double-sided surface mounting technology, electronic assembly operation. Six control factors and interaction effects were studied using an L8 OA experiment advocated by Taguchi [11]. In addition, Irena Šabarić, Snjenaza Brnada, Stana Kovacevic (2013) conducted research entitled Application of the MODAPTS Method with Innovative Solutions in the Warping Process, located in Zagreb-Croatia. This study aims to eliminate ineffective movements in the process of compiling yarn rolls in textile companies by designing innovative work aids. The results of the study state that from the motion study calculation using MODAPTS can save time by 75.87% mods after repairs due to the simplification of work movements using innovative trolleys [12].

Taguchi Methods involve reducing variations of the process through the robust design of the experiment. The main objective of this method is to produce high quality products at very low costs. Taguchi developed a method for designing experiments to be able to investigate the effect of different parameters on the mean and the variance of the performance characteristics of the process that determines how well the process is functioning. The experimental design introduced by Taguchi involves orthogonal arrays to organize parameters that influence the process and levels that need to be varied. Taguchi Methods do not test all possible combinations but only test a few combinations. This test will produce a collection of important data that can determine what factors most influence product quality with minimum experimentation to save time and money.

## 2 Methodology

The research was conducted at one of the factories engaged in aluminum smelting production. The object of the researchers observed was the changing anode and the operator's working method where the research was conducted in August 2015. The type of research design used was a type of causal research. This is because this study was conducted to investigate causal relationships by observing the

consequences that occur and the possible factors (causes) that cause these effects [13]. Problem-solving is done by calculating the Loss Function of the variations that occur, then making improvements to the work method.

Consumer products and services are now increasingly critical of the products offered by producers. In addition to paying attention to the prices offered, more attention to the quality of goods or services offered by producers. Therefore, producers must also pay attention to the quality of products or services offered to consumers in order to maintain or expand market share.

There are several types of quality control, including:

1. Inspection
2. Quality control with the Taguchi Method
3. Statistical quality control

The general steps in Taguchi Methods are as follows:

- Determine the purpose of the process or more specifically the target value for measuring the performance of a process.
- Determine the design parameters that influence the process
- Make orthogonal arrays to design parameters that indicate the number and conditions of each experiment
- Connecting experiments indicated on arrays that have been completed to collect data on the effects of performance measurements
- Complete data analysis to determine the effect of various parameters on performance measurement.
- The Taguchi Method is best used when there are intermediate numbers of variables (3 to 50), small interactions between variables, and when only a few variables make a significant contribution.

In Taguchi Method, the word "optimization" implies "determination of BEST levels of control factors". In turn, the BEST levels of control factors are those that maximize the Signal-to-Noise ratios. The Signal-to-Noise ratios are log functions of desired output characteristics. The experiments, that are conducted to determine the BEST levels, are based on "Orthogonal Arrays", are balanced with respect to all control factors and yet are minimum in number. This in turn implies that the resources (materials and time) required for the experiments are also minimum.

Taguchi Method is a process/product optimization method that is based on 8-steps of planning, conducting and evaluating results of matrix experiments to determine the best levels of

control factors. The primary goal is to keep the variance in the output very low even in the presence of noise inputs. Thus, the processes/products are made ROBUST against all variations.

### 2.1. Steps

The data processing stage that is carried out is:

- a. Calculating Loss Function from variations that occur using anode and AVV height data (Average Voltage)
- b. Improvement of work methods
  1. Map of the left hand and right hand
  2. Modular Arrangement of Predetermined Time Standards (MODAPTS)

## 3 Result and Discussion

### 3.1. Calculating Loss Function

Taguchi defines quality as a loss in a society starting from the delivery of a product. Losses include expenses, waste, and opportunities lost due to the

inaccuracy of the product against the target value [10]. Taguchi creates a loss function as an equation:

$$L(y) = kv^2$$

Information:

$v^2$  = the standard deviation of the target value of the height of the anode

$$k = \frac{A}{\Delta^2}$$

A = the amount of loss due to the deviation is the average AVV used

$\Delta^2$  = predetermined specifications

### 3.2 Operator Work Method Movement

In order for the pot voltage to remain stable, the anode replacement must be adjusted, every day 1 anode can be replaced. The operator movement will be described as a movement element based on the Modapts method. Work movements carried out by operators can be seen in Table 1.

Based on Table 1, basically, the body movements in this method are Therblig movements which are refined to become more detailed.

**Table 1.** Recapitulation of Operator Work Movements

No	Work	Movement Elements	Movement of Modapts
1		Turning on crane	Finger, hand, forearm, whole arm, extended arm, Grasp, press, eye regrasp
2		Bring the crane to the pot area	Finger, hand, forearm, whole arm, extended arm, Grasp, press, eye regrasp
3		Gripping the anode to be replaced	Finger, hand, forearm, whole arm, extended arm, Grasp, press, eye regrasp
4		Removed the old anode	Finger, hand, forearm, whole arm, extended arm, Grasp, press, eye regrasp
5		Observe the old anode	Stand, eye
6		Bring the old anode out of the pot	Finger, hand, forearm, whole arm, extended arm, Grasp, press, eye regrasp
7	ANODA CHANGING	Place the anode above the comparison	Finger, hand, forearm, whole arm, extended arm, Grasp, press, eye regrasp
8		Put it on the pallet	Finger, hand, forearm, whole arm, extended arm, Grasp, press, eye regrasp
9		Check the state of the pot	Stand, eye
10		Place the new anode above the comparison	Finger, hand, forearm, whole arm, extended arm, Grasp, press, eye regrasp
11		Bring the anode to the place that is replaced	Finger, hand, forearm, whole arm, extended arm, Grasp, press, eye regrasp
12		Setting up a new anode	Finger, hand, forearm, whole arm, extended arm, Grasp, press, eye regrasp
13		Bring the crane out of the pot and switch to another pot	Finger, hand, forearm, whole arm, extended arm, Grasp, press, eye regrasp

### 3.3. Improvement of Operator Work Movement

Based on the economic principles of the movement, the worker's movement of the operator must fulfill the principles contained in the movement economy. The operator's work movements that are not in accordance with the principles of movement economics are shown in Table 2.

### 3.4. Processing Time

Calculation of process time is done by the Modular Arrangement of Predetermined Time Standards (MODAPTS) method. In the actual working method, operators often make mistakes when replacing anodes, such as repetition of movements, workload imbalances between the left and right hands, and other operator errors, operators should be able to use idle time to maximize work movements when adjusting the height of the anode. Proposed improvements are made by reducing work (elimination) or repetitive movements and idle movements of all operators.

**Table 2.** Incompatible Operator Work Moves

No	Principles of Movement Economics	Operator Movement
1	Both hands must start and end their movements at the same time.	The operator's hand does not start and end the movement at the same time.
2	The movement of the body is saved, which is only moving the body parts that are needed to do the best work possible.	Operators use 42.4% and 38.6% of their body in the anode setting process.
3	Avoid movements that cause changes in direction because they will spend more time	There is no movement that causes changes in direction in the anode setting process
4	Place materials and work facilities in an easy and fast place to reach	Operator room is to be limited because of the space is very small, it is causing operator limited to make a movement when perform their task.

## 4 Conclusion

One particular causative factor that causes variation in the method of work carried out by the operator which later will directly affect the quality of the process. Based on this study, the Taguchi loss function method is used to calculate the amount of loss experienced by the company due to the variation by seeing the amount of power released during the activity. The total losses suffered by the company in Block 1 amounted to Rp 19,733,263, while the total loss in Block 2 was Rp 35,919,435. The results of the analysis of the operator's work method, namely the operator's movements are not in accordance with the economic principles of movement, namely the operator's hands do not start and end the movement at the same time, operator movement that should not be done when adjusting the new anode height, and operator space within the crane is limited because the area is too narrow. Comparison of the standard time of actual and proposed work methods is 774,847 seconds and 648.2 seconds with a time difference of 126,647 seconds faster and there is no movement that should not be done by the operator so the operator can use the time to adjust the anode height as well as possible according to the standards has been determined by the company.

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