ISSN: 2350-0328
International Journal of AdvancedResearch in Science, Engineering and Technology
Vol. 5, Issue 11, November 2018

Mathematical Modeling according to the Time of the Instantaneous Stop of the Plant

Chi SangPark, Juyoung Jang, Jonghwan Lee*

Graduate Student, School of Industrial Engineering, Kumoh National Institute of Technology, Gumi, South Korea
Graduate Student, School of Industrial Engineering, Kumoh National Institute of Technology, Gumi, South Korea
*Professor, School of Industrial Engineering, Kumoh National Institute of Technology, Gumi, South Korea

ABSTRACT: Mathematical modeling of instantaneous stop is possible by the time and the number of instantaneous stops.In this study, mathematical modeling is performed according to the time of instantaneous stop rather than the number of times. The mathematical modeling can be used to calculate the instantaneous stopping ratio and MTBE (Mean Time Between Error).In the improvement method based on the instantaneous stop time, the instantaneous stop time including the MTBE, the instant stopping ratio, the operation time, the operation ratio, and the operation cycle are considered for each facility. And then, it is divided into individual facilities and total facilities for semi-chronic, chronic, and unexpected types.

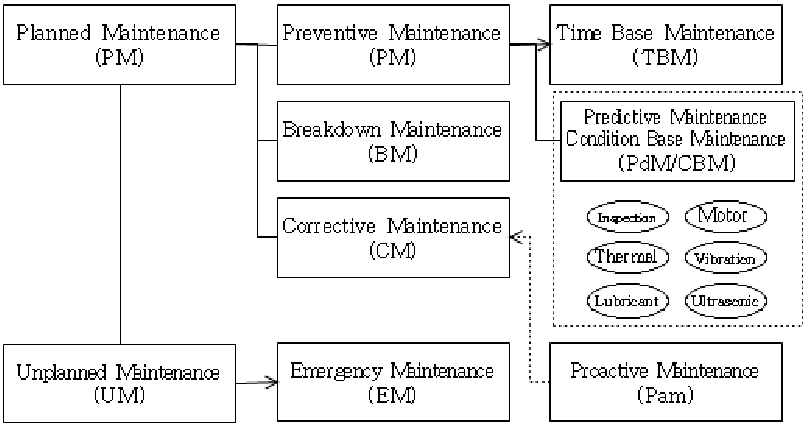
KEY WORDS: Time of Instantaneous Stop, Semi-Chronic Type, Chronic Type, and Unexpected Type, MTBE(Mean Time Between Error), Instantaneous Stopping Ratio

I.INTRODUCTION

A. Facility Maintenance Activity

The facility maintenance activity is to establish the inspection system (inspection activity) and investigate the deterioration phenomenon of the equipment to predict which part of the equipment will be repaired and to prepare the necessary materials and personnel for the planned repair. Equipment maintenance includes Breakdown Maintenance, Time Based Maintenance, Condition Based Maintenance, Preventive Maintenance, Productive Maintenance and Quality Maintenance. Classification of conservation activities is not separated, but basically can be divided into preventive maintenance and post-conservation. And, the most efficient way of conservation depends on the conditions of operation of facilities, type of equipment, factors of manpower, management strategy and policy. However, if we expand the scope more, facility maintenance can be divided into maintenance activities and improvement activities. Various methods have been developed depending on the change of equipment technology and production method. This maintenance activity can be largely divided into Scheduled Maintenance and Unscheduled Maintenance .Figure 1 shows the classification and relationship of facility maintenance activities.

ISSN: 2350-0328
International Journal of AdvancedResearch in Science, Engineering and Technology
Vol. 5, Issue 11, November 2018



[Figure 1] Classification and Relationship of Facility Maintenance

B. Instantaneous Stop

Unlike the failure, temporary stoppage causes the equipment to stop or idle. It is accompanied by a momentary stoppage of the function. Recovery of the function is possible with simple measures, and does not involve part replacement or repair. Momentary stopping tends to be left untreated, and even if the same product is likely to be overlooked due to the date or equipment, it is likely to occur intensively in some areas or intensively in other areas. It is difficult to grasp its identity. It is also possible to quantitatively grasp the site of occurrence, frequency, and time of action, but it is difficult to continue. However, in general, the efficiency of the equipment is largely hindered by this small trouble, and in particular, it is a phenomenon that occurs frequently in an automatic machine, an automatic assembly machine, and a conveying facility. To reduce instantaneous stoppages, it is important to analyze the phenomenon in detail and to thoroughly eliminate imperfections.

There are several reasons for the momentary stoppage. First, facility reliability is low. The problem is that reliability is low due to poor equipment, and there is a large amount of scatter in parts and assembly fluctuations .In addition, workers are unstable in using facilities and have low reliability in use and low maintenance due to poor maintenance. The quality reliability of the whole process also becomes a problem .In addition to the case where unprocessed product is mixed with poor process control, equipment often stops due to the dimension and weight of the semi-finished product, or the product mixes with different products and defects in shape.

As a method for reducing failure and instantaneous stoppage, sudden death can be solved only by observing what is different in equipment or product. However, chronic type pauses do not understand what is going on because they have caused continuous problems from the beginning to the present. Chronic type is due to the fact that there is an error somewhere in design, specification, manufacture, processing, assembling, and installation, which is a use condition of the facility, but it can not be precisely known. An activity that eliminates a momentary stop is not an elimination of a sudden stop, but an activity that eliminates this chronic stop. It is desirable to manage MTBE (Mean Time Between Error) or MTBAF (Mean Time Between A Fault) through the management of the number of instant pauses and time .In addition, it is desirable to classify the instantaneous stopping into chronic type and sudden type instead of collectively.

Among the various troubles of the automation equipment, the instant stoppage belongs to the problem that is hard to solve in the field because the quantitative grasp of the trouble itself and the change of the phenomenon are very severe. In order to solve such a problem, quantitative analysis is required to know precisely the occurrence state and the amount of generation of the instantaneous suspension trouble. However, it is not enough to quantitatively analyze the loss caused by instantaneous stoppage and to utilize it to establish countermeasures. Instantaneous shutdown is not a malfunction but a phenomenon in which an automatic facility detects a temporary trouble and stops automatically and returns to its original state according to the simple operation of the operator in a public operation state due to a cycle time difference between peripheral automation facilities. The instantaneous shutdown of the automation equipment is easy to overlook because it is simple to treat and difficult to surface as a problem. Therefore, there is a tendency that fundamental measures are not established and left unattended.

ISSN: 2350-0328
International Journal of AdvancedResearch in Science, Engineering and Technology
Vol. 5, Issue 11, November 2018

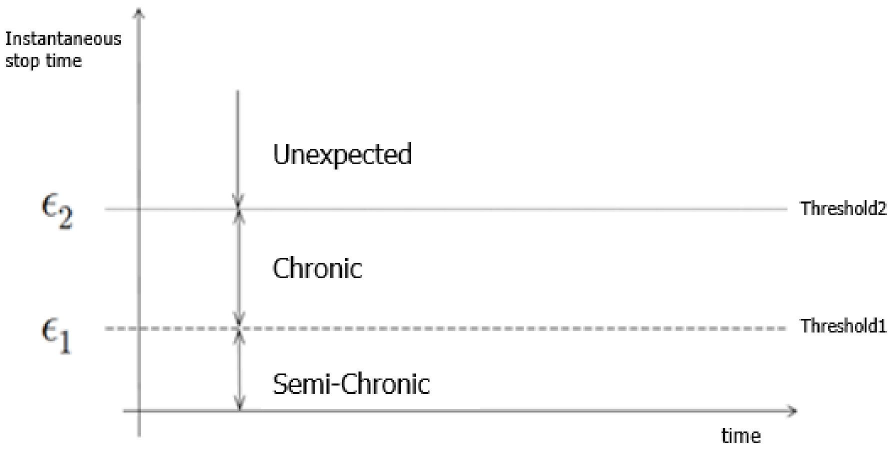
Depending on the shape of the product or part, the same product is likely to be ignored because the cause and frequency of occurrence are different and the cause of the instant stoppage is not present. In addition, it is difficult to grasp the cause of the cause because the site is moved or changed. If one part is improved, the site is improved, but the other part is not formed, and the whole is not improved, and the chronic case and the chronic case occur simultaneously .Therefore, it is difficult to quantitatively understand the number of times of instantaneous stoppage, time, etc., so that it is not a momentary stop but a long and large loss because it is left without paying attention to occurrence of troubles. The phenomenon and causes of instantaneous stoppages occur differently in each business establishment.

II. MATHEMATICAL MODELING BY THE TIME OF INSTANTANEOUS STOP

It is subdivided into semi-chronic (E1), chronic (E2), and unexpected (E3) in order to make instantaneous stop into a mathematical model. A mathematical model for E1, E2, and E3 is constructed so that it is easy to identify the phenomenon and analyze the cause of the facility automatically input. Then, the stop time and stop rate, the operation time, the operation ratio, and the operation cycle of the instant stop for each are calculated. It provides a quantitative indicator of the management concept in seconds for each instantaneous stop, which is a compass in the direction of improvement. When defining a set of instantaneous stop as a TE (Time Elapsed Error), the defined set can be defined as the following equation (1).

$$TE = \{ET_{i(x)}\},\ x = \{B, L, V\} \quad (1)$$

$ET_{i(x)}$, which is an element of TE, x represents the individual components that make up the automation system as Equation (1). T_i represents the time from occurrence of the i-th instantaneous stop to completion. As a result, $ET_{i(x)}$ means the i-th instantaneous stopping time that occurs during the $T_i$hour in the plant component x. The instantaneous stop by time is divided into semi-chronic, chronic and unexpected as shown in [Figure 2], and thresholds for detailed classification are defined as ϵ_1 and ϵ_2. ϵ_1 is the threshold value of small chronicity and the threshold value of chronicity and chronicity, and ϵ_2 is the chronic threshold, which means the boundary value of chronic and eruptive.



[Figure 2] Definition of Instantaneous Stop Set by Time

TE_1, TE_2, and TE_3 in equations (2), (3), and (4) represent a set of semi-chronic, chronic, and unexpected sets of instantaneous stopping over time.Equation (5) and equation (6) are formulas for determining thresholds for distinguishing semi-chronic, chronic, and unexpectedtype.The total sum of the instantaneous stoppages at time x is expressed as the sum of semi-chronic, chronic, and unexpected as in equation (7).For each facility, the actual stopping time, instant stop rate, operation time, operation ratio, and operation cycle including MTBE are divided into semi-chronic, chronic, unexpected, individual facility, and total facility.T used in the following equation means total operation time and C means cycle constant.

ISSN: 2350-0328
International Journal of AdvancedResearch in Science, Engineering and Technology
Vol. 5, Issue 11, November 2018

$$TE_1 = \{ E_1 T_{i(x)} < \epsilon_1 \} \quad (2)$$

$$TE_2 = \{ \epsilon_1 \leq E_2 T_{i(x)} < \epsilon_2 \} \quad (3)$$

$$TE_3 = \{ E_3 T_{i(x)} \geq \epsilon_2 \} \quad (4)$$

$$\epsilon_1 = \sigma \times \delta - \overline{TE} \quad (5)$$

$$\epsilon_2 = \sigma \times \delta + \overline{TE} \quad (6)$$

$$TE_{(x)} = \sum_i E_1 T_{i(x)} + \sum_i E_2 T_{i(x)} + \sum_i E_3 T_{i(x)} \quad (7)$$

Equations (8), (9), and (10) represent the percentage of downtime for individual plant components due to semi-chronic, chronic, and unexpected. Equations (11), (12), and (13) represent the MTBEs that correspond to the individual plant components of the semi-chronic, chronic, and unexpected. Equation (14) represents the MTBE of individual plant components, including both semi-chronic, chronic, and unexpected, and Equation (15) represents the MTBE of the entire plant, including semi-chronic, chronic, and unexpected.

$$TE_1 R(x) = \frac{\sum_i E_1 T_{i(x)}}{T} \quad (8)$$

$$TE_2 R(x) = \frac{\sum_i E_2 T_{i(x)}}{T} \quad (9)$$

$$TE_3 R(x) = \frac{\sum_i E_3 T_{i(x)}}{T} \quad (10)$$

$$MTBE_1(x) = \frac{T - \sum_i E_1 T_{i(x)}}{nTE_1} \quad (11)$$

$$MTBE_2(x) = \frac{T - \sum_i E_2 T_{i(x)}}{nTE_2} \quad (12)$$

$$MTBE_3(x) = \frac{T - \sum_i E_3 T_{i(x)}}{nTE_3} \quad (13)$$

$$MTBE(x) = \frac{T - (\sum_i E_1 T_{i(x)} + \sum_i E_2 T_{i(x)} + \sum_i E_3 T_{i(x)})}{nTE_1 + nTE_2 + nTE_3} \quad (14)$$

ISSN: 2350-0328
International Journal of AdvancedResearch in Science, Engineering and Technology
Vol. 5, Issue 11, November 2018

$$MTBE = \frac{T - (\sum_x \sum_i E_1 T_{i(x)} + \sum_x \sum_i E_2 T_{i(x)} + \sum_x \sum_i E_3 T_{i(x)})}{nTE_1 + nTE_2 + nTE_3} \qquad (15)$$

Equation (16), equation (17), and equation (18) represent the instantaneous stopping rate for each of the semi-chronic, chronic, and unexpected facilities, and equation (19) represents the instantaneous stop rate for the entire facility, including all semi-chronic, chronic, and unexpected type.

$$TE_1R = \frac{\sum_x \sum_i E_1 T_{i(x)}}{T} \qquad (16)$$

$$TE_2R = \frac{\sum_x \sum_i E_2 T_{i(x)}}{T} \qquad (17)$$

$$TE_3R = \frac{\sum_x \sum_i E_3 T_{i(x)}}{T} \qquad (18)$$

$$TER = \frac{\sum_x \sum_i E_1 T_{i(x)} + \sum_x \sum_i E_2 T_{i(x)} + \sum_x \sum_i E_3 T_{i(x)}}{T} \qquad (19)$$

Equations (20), (21), and (22) represent the operating time for individual plant components due semi-chronic, chronic, and unexpected type and equation (23), equation (24), and equation (25) represent the operating ratio.

$$TE_1Rt = T - \sum_x \sum_i E_1 T_{i(x)} \qquad (20)$$

$$TE_2Rt = T - \sum_x \sum_i E_2 T_{i(x)} \qquad (21)$$

$$TE_3Rt = T - \sum_x \sum_i E_3 T_{i(x)} \qquad (22)$$

$$TE_1R = 1 - \frac{\sum_x \sum_i E_1 T_{i(x)}}{T} \qquad (23)$$

$$TE_2R = 1 - \frac{\sum_x \sum_i E_2 T_{i(x)}}{T} \qquad (24)$$

$$TE_3R = 1 - \frac{\sum_x \sum_i E_3 T_{i(x)}}{T} \qquad (25)$$

ISSN: 2350-0328
International Journal of AdvancedResearch in Science, Engineering and Technology
Vol. 5, Issue 11, November 2018

Equations (26), (27), and (28) represent the operating time for all plant components due to due semi-chronic, chronic, and unexpected type, equation (29), equation(30), equation(31) represent the operation ratio.

$$TE_1Rt = T - \sum_x \sum_i E_1 T_{i(x)} \tag{26}$$

$$TE_2Rt = T - \sum_x \sum_i E_2 T_{i(x)} \tag{27}$$

$$TE_3Rt = T - \sum_x \sum_i E_3 T_{i(x)} \tag{28}$$

$$TE_1R = 1 - \frac{\sum_x \sum_i E_1 T_{i(x)}}{T} \tag{29}$$

$$TE_2R = 1 - \frac{\sum_x \sum_i E_2 T_{i(x)}}{T} \tag{30}$$

$$TE_3R = 1 - \frac{\sum_x \sum_i E_3 T_{i(x)}}{T} \tag{31}$$

Equations (32), (33), and (34) represent the operating cycles for individual plant components due to due semi-chronic, chronic, and unexpected type, equations (35), (36), and (37) represent the operating cycles for all plant components.

$$TE_1C(x) = \frac{T - \sum_i E_1 T_{i(x)}}{c} \tag{32}$$

$$TE_2C(x) = \frac{T - \sum_i E_2 T_{i(x)}}{c} \tag{33}$$

$$TE_3C(x) = \frac{T - \sum_i E_3 T_{i(x)}}{c} \tag{34}$$

$$TE_1C = \frac{T - \sum_x \sum_i E_1 T_{i(x)}}{c} \tag{35}$$

$$TE_2C = \frac{T - \sum_x \sum_i E_2 T_{i(x)}}{c} \tag{36}$$

ISSN: 2350-0328

International Journal of AdvancedResearch in Science, Engineering and Technology

Vol. 5, Issue 11, November 2018

$$TE_3C = \frac{T - \sum_{x}\sum_{i} E_3 T_{i(x)}}{c} \quad (37)$$

III.CONCLUSION AND FUTURE WORK

The first step in the methodology to improve instantaneous stopping is to classify the instantaneous stop as a three types, Semi-chronic type (E1), Chronic type (E2), and Unexpected type (E3).After analysis of semi-chronic, chronic, and unexpected type, mathematical modeling of the frequency of instantaneous stops was implemented at the previous research. Through this study, mathematical modeling according to time of instantaneous stop was completed. Mathematical modeling can be used to derive the MTBE and the rate of instantaneous shutdown.

REFERENCES

[1] Hyun Woo Lee, Jae Woo Kim, S. H. Park, "MTBF Estimator in Reliability Growth Model with Application to Weibull Process", The Korean Society for Quality Management", 1998, pg no: 71-81.

[2] Young-In Kim, Byung-Kwan Choi, Hyo-Joon Hahn, " The Efficient TPM Application Based on the Manufacturing Characteristics for Semiconductor Industry", Journal of the Korean Institute of Plant Engineering, 2003, pg no : 5-20

[3] "Managerial Requirements for the Successful Implementation of TPM",Journal of the Korean Institute of Plant Engineering, 2009, pg no: 119-124.

[4] Won-Tae, Tae-Young Song, Hyo-Joon Hahm, "A Study on the Role of Scheduled Maintenance in TPM Activity", Journal of the Korean Institute of Plant Engineering, 2005, pg no: 47- 53

[5]Jung-Sik Kim, "On the Appraisal Factors for Maintenance Management in TPM", Journal of the Korean Institute of Plant Engineering, 2016, pg no: 99- 108

[6]Chae Heung Park, "The Effect and Influencing Mechanism of TPM Factors to Performance", The Korean Society for Quality Management", 2002, pg no: 154-163

[7]Yong-Keon Lee, Tae-Soo Rye, "A Case Study of Six Sigma and TPM's Integrated Methodology for Manufacturing Innovation", Journal of the Korean Institute of Plant Engineering, 2011, pg no: 93-101

[8] Robert W. Holtz, Paul A. Cambell, "Six Sigma : It's Implementation in Ford's Facility Management and Maintenance Functions", Journal of Facilities Management, 2004, pg no.: 31-40

[9] Cochrance, D., "Breathing New Life into TPM, Works Management, 2003, pg no.: 30-33

[10] Taesu Hwang, Cheol-Seok Kim, Juyoung Jang, Jonghwan Lee, "Classification of Instantaneous Stop for Machine Maintenance", International Journal of Advanced Research in Science, Engineering and Technology, 2018, pg no: 6304-6308

[11] Juyoung Jang, Jonghwan Lee, "Mathematical Modeling to Calculate the Ratio of Instantaneous Stop and MTBE using Instantaneous Frequency", International Journal of Advanced Research in Science, Engineering and Technology, 2018, pg no: 6503-6506