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Mathematical Modeling to Calculate the Ratio of Instantaneous Stop and MTBE using Instantaneous Frequency

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ABSTRACT: In this paper, in order to improve the efficiency of the automation facility, the instantaneous stop of the individual equipment of the automation system is divided into three parts: semi-chronic, chronic, and unexpected. A mathematical model is established to improve facility management efficiency by the number of instant stoppages. In mathematical modelling, the number and rate of instantaneous stop can be calculated for each part for each facility. In addition, the mathematical model can calculate the instant stopping time, the instant stopping ratio, the operation time, the operation ratio, and the operation cycle including the MTBE (Mean Time Between Error) for each facility.Then, it can be calculated after dividing the facility into individual facilities and entire facilities. Mathematical model is obtained by the number of instantaneous stop.

KEYWORDS: Classification, Instantaneous Stop, Semi-Chronic Type, Chronic Type, and Unexpected Type, MTBE(Mean Time Between Error)

I.INTRODUCTION

In this study, we propose a methodology to solve the problems caused by instant stop. The developed methodology aims to make the plant operator easy to use and to accomplish instant stop zeroing. In order to solve the instant stop problem, it must be quantified. The proposed methodology proposes a mathematical model for quantification of each instantaneous stop through the number and time of instantaneous stops. We propose a methodology for designing and analyzing a mathematical model through instantaneous stop analysis. We analyze the methodology based on the number of instantaneous stoppages and the methodology based on time, and verifies the efficiency of the proposed method that can be used for the factory management of the automation system by using case data from actual manufacturing sites.
For the mathematical model design, the improvement method by the number of instant stopping and the improvement method by the instant stopping time are divided.
The instantaneous stoppage using the calculated formula is used to determine the instantaneous stoppage by the condition setting, so that it is possible to automatically distinguish each functional part by facility. The formula for calculating the instant stoppage ratio and the MTBE for each is shown. This provides priorities for improvements, and the graphs and quantified values that are presented can be used as KPIs (Key Performance Indicators)
Facility management increases enterprise productivity or reduces opportunity loss. It refers to all activities that take measures to maximize the functions of the facility by planning, maintaining and improving facilities in accordance with corporate policy to improve profitability. There is a wide range of facility management covering both the life cycle of the facility, the stage from the creation of the facility to the stage after the creation, and the facility management of the consultation for the post-generation phase only. Broad facility management refers to the management of activities that increase the productivity of the enterprise by effectively utilizing facilities through the lifecycle of the equipment that is finally discarded through the investigation, research, design, manufacture and installation of the equipment, operation and maintenance.
The facility management of the consultation means the stage after the creation of the facility, that is, the maintenance of the facility after the installation is completed. In order to improve the productivity of the enterprise, it is not sufficient to manage the facilities after the creation of the facilities, that is, the consultation, and the management of the facilities is required. As the automation of the facilities progresses, there are various types of troubles of the facilities. Trouble in the automation equipment is often a reproducible degradation type trouble, and there are many black box parts whose

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cause is unknown, so it was difficult to cope with the maintenance. The effects of automation equipment trouble on manufacturing management can be summarized in terms of productivity, quality, cost, delivery, safety, and motivation of workers.

Table 1. Method of Facility Maintenance

	Maintenance Classification	Maintenance Method	Pros and Cons
Maintenance perspective	BM Breakdown Maintenance	Repairing, replacing, etc. after a failure without repairing, regular replacement, etc.	Increased chances of chain failures as the parts are used up to the end of the service life, resulting in increased load on the economic failure area, affecting production, and increasing the action time per component due to lack of spare parts and labor.
	TBM TimeBased Maintenance	Detects degradation of equipment and parts, and cycle and time of occurrence of failure.	Unexpected breakdowns are reduced, and planned maintenance operation creates a workforce reduction effect. It is important to observe the specified period to perform maintenance work, which may lead to excessive maintenance.
	CBM Condition Based Maintenance	The method of preservation when reaching certain standard through analysis of core parameters related to equipment deterioration and performance degradation	It is preserved according to equipment and parts condition, so it can save the optimum number of maintenance and cost System construction and related costs are added for monitoring core parameters, accumulation of related data and systematic analysis are needed.
Improvement perspective	CM Corrective Maintenance	It improves and improves facility reliability and integrity by modifying weak points so that failures and failures do not recur.	Reduced maintenance and cost by improving reliability and integrity It can be distorted due to lack of technology and sufficient review, and it is necessary to judge in terms of ROI.
	CBM Condition Based Maintenance	Facility design, method of minimizing maintenance by improving weakness from the time of production	Maintenance costs can be minimized in terms of operation, resulting in an increase in initial purchase costs

II. MATHEMATICAL MODELLING

A. Improvement Method by the Number of Instantaneous Stop

Constructing a mathematical model for E1, E2, E3 (semi-chronic type, chronic type, and unexpected form) so that it can be easily grasped and analyzed.It is suggested that the number and rate of instantaneous stop for each will be calculated, which is the guideline for improvement direction.
When the total set of instant stop is called ME (Momentary Error), the defined set ME is defined in (1). In the formula,E_i, which is the element of ME, t_j represents the j-th time, and x represents the individual components that make up the automation system.B (Bowl Feeder), L (Line Feeder) and V (Vacuum) are defined as x.
E_i represents the instantaneous stop.As a result, $E_{i(tj,x)}$ means the i-th instantaneous stop occurring at time t in the plant component x.

$$ME = \{E_{i(t,x)}\}, x = \{B, L, V\} \quad (1)$$

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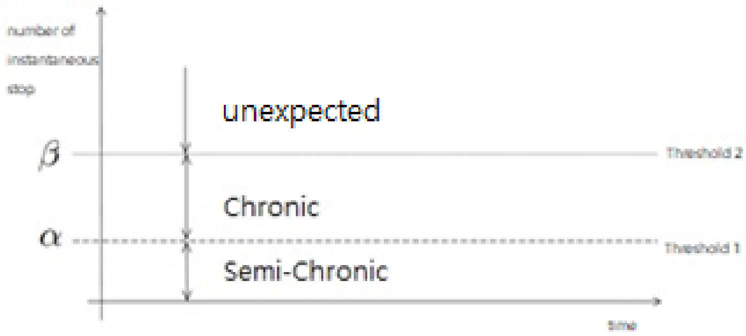
As shown in [Figure 1], the instantaneous stop by the number of times proposed in this paper is divided into semi-chronic, chronic and unexpected type, and the thresholds for distinguishing them are defined as α and β. α is the threshold value of semi-chronic and the threshold value of semi-chronic and chronic type, and $\beta$is the chronic threshold, which means the boundary value of chronic and unexpected.



[Figure 1]Definition of Instantaneous Stop Set

EE in equation (2) represents the set of proposed instantaneous stops.In the conventional method, instantaneous stop is determined using only the threshold valueα. $C_{i(x)}$in the equation (2) represents the number of instantaneous stops of the i-th occurrence of α or more in the individual component x.

$$EE = \left\{ C_{i(x)} \geq \alpha \mid C_{i(x)} = \sum_i E_{i(t,x)} \right\} \tag{2}$$

Equation (3) represents the total number of $C_{i(x)}$ instant stop proposed in the existing method, and equation (4) represe nts the instant stop of $ER_{(x)}$ individual component x.

$$EC = \sum_x \sum_i C_{i(x)} \tag{3}$$

$$ER_{(x)} = \frac{\sum_i C_{i(x)}}{EC} \tag{4}$$

EE_1,EE_2, and EE_3in equations. (5), (6), and (7) represent a set of semi-chronic, chronic, and unexpected type of the instantaneous stop by the number of times proposed in this paper. The sum of the instantaneous stops at x is expressed as the sum of the semi-chronic, chronic, and the number of unexpected as shown in equation (8).In the proposed paper, the ratio of semi-chronic, chronic, and unexpected can be obtained from equations. (9), (10), and (11).

$$EE_1 = \left\{ E_1 C_{i(x)} < \alpha \mid E_1 C_{i(x)} = \sum_i E_{i(t,x)} \right\} \tag{5}$$

$$EE_2 = \left\{ \alpha \leq E_2 C_{i(x)} < \beta \mid E_2 C_{i(x)} = \sum_i E_{i(t,x)} \right\} \tag{6}$$

$$EE_3 = \left\{ E_3 C_{i(x)} \geq \beta \mid E_3 C_{i(x)} = \sum_i E_{i(t,x)} \right\} \tag{7}$$

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$$EC_{(x)} = \sum_i E_1 C_{i(x)} + \sum_i E_2 C_{i(x)} + \sum_i E_3 C_{i(x)} \quad (8)$$

$$E_1 R_{(x)} = \frac{\sum_i E_1 C_{i(x)}}{EC_{(x)}} \quad (9)$$

$$E_2 R_{(x)} = \frac{\sum_i E_2 C_{i(x)}}{EC_{(x)}} \quad (10)$$

$$E_3 R_{(x)} = \frac{\sum_i E_3 C_{i(x)}}{EC_{(x)}} \quad (11)$$

III.CONCLUSION AND FUTURE WORK

The mathematical model was designed to grasp the phenomenon of instantaneous stop, analyze the cause, and present alternatives. The first step in the mathematical model is mathematical modelling by the number of instant stops. We have modelled the number and rate of instantaneous stop as the result, and setting the direction of improvement and proceed with the improvement. Next step is modelling a mathematical formula and develop a method by the number of instantaneous stop to identify the reason of breakdown and analyse the cause more effectively.

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