ESTIMATION OF LABOR WORK ACTIVITY BASED DEFECT RATE IN PART PER MILLION PROCESS

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Abstract:
Due to major in improvement in manufacturing process during the last decade, many manufacturing companies performance have achieved a very low defect rate around one to three percent. However, the lower defect rates are, the higher the pressure from customers in zero defect delivery. To ensure highest customer satisfaction and quality reputation, quality related activities, such as product inspection, process monitoring, and process adjustment, are added into typical production activity. Since problems related to product quality seems to occur randomly. It is very difficult to determine the appropriate number of operators in particular when the given production line produce several products that has different characteristics in product quality problems. This research aims to develop an estimation method that provide a required time for defect correction and inspection related activity. By using statistical techniques, the distribution of each defects are identified. Then, the probability of defect occurence based on production target can be estimated. The time of the operator activity related to each defect can be estimated based on this probability and standard correctioin time. In this research, in certain types of defects can not be directly identifed its distribution. As a results, central limited theorm has been brought to identify the rate of defect, such as piece per hour, in normal distribution form. To validate, this proposed method in estimated the time of defect correction activity is compared with time motion study method.

Keywords: work estimation, continuous process monitoring, defect distribution

1. INTRODUCTION

Due to major in improvement in manufacturing process during the last decade, many manufacturing companies performance have achieved a very low defect rate around one to three percent. However, the lower defect rates are, the higher the pressure from customers in zero defect delivery. To ensure highest customer satisfaction and quality reputation, quality related activities, such as product inspection, process monitoring, and process adjustment, are added into typical production activity. As a result, many factory has assigned the work to operator who typical not only monitoring the process for a major problem but also to adjust/fix the process in regards to the number of defects reported by the end of its production line. So that the problem can quickly be solved. Since problems related to product quality seems to occur randomly. It is very difficult to determine the appropriate number of operators in particular when the given production line produce several products that has different characteristics in product quality problems.

This inability to estimate workload of operator leads to improper quote the product price to customer. In the case of process industry which usually an upstream manufacturer where large volume order is common with smaller margin that downstream player like retailer. Therefore, the accuracy of costing in particular operating cost is very crucial for company.

In this research, we focus on process industry which produce discrete item. Its average performance is about 99% of production yield (1% of Defects) where there are about 100 types of defects of that 1% defects. However, in this research we focused on only top 20 types of defects which cover 80% the number of defects.

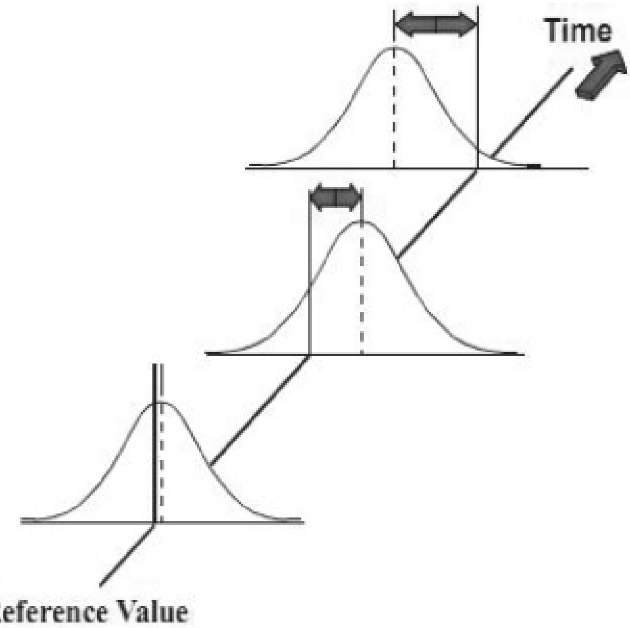
2. LITERATURE REVIEW

A control chart is a statistical tool used as a tool to continuously monitor and make adjustments to the product or process. It is also used to distinguish between variation in a process resulting from common causes and variation resulting from special causes. In addition, control charts are a means of graphing variation patterns from process or product characteristics so that corrective action may be taken if required. It presents a graphic display of process stability or instability over time, not performance (Montgomery, 2005). Montgomery (2005) described that the control chart distinguishes between normal and non-normal variation through the use of statistical tests and control limits. The control limits are calculated using the rules of probability so that when a point is determined to be out of control, it is due to an assignable cause and not due to normal variation. Points outside the control limits are not the only criteria to determine out of control conditions. All points may be inside the limits and the process may still be out of control if it does not display a normal pattern of variation. Zone tests are used to determine out of control conditions. Zone tests are hypothesis tests in a modified form. They are used to test if the plotted points are following a normal pattern of variation.

Control charts were one of the first statistical techniques introduced in statistical quality control. Dr. Walter A. Shewhart of AT&T Bell Laboratories developed the charts in 1924. The original charts for variables data, x bar and R charts, were called Shewhart charts. Currently, the purpose of the control chart is to indicate whether or not a process is in statistical control. Statistical control means that the plotted points follow a pattern of variation consistent with the areas under the normal curve. There are two types of control charts: the variables control chart and the attributes control chart. The variables charts use actual measurements as data and the attribute charts use percentages or counts.

For most processes, the total variation is usually described as a normal distribution. Normal probability is an assumption of the standard methods of measurement systems analysis. In fact, there are measurement systems that are not normally distributed. When this happens, and normality is assumed, the MSA method may overestimate the system error. The measurement analyst must recognize and correct evaluations for non-normal measurement systems.

Figure 1: Process Variation due to defects



3. METHODS

First, the types of defects must be identified in association with inspection or correction activity. As shown in equation (1).

$$\left\lceil prob(defect_i \geq 1\%) \mid prob\_of\_occurance(defect_i) * Time \right\rceil \quad (1)$$

Then, the probability distribution of each defect must be identified. However, due to the low level of defect occurrences, the distribution of occurrence for each type of defects cannot be statistically identified as shown in picture below (Chernoff and Lehmann, 1954).

Figure 2: Statistical Process Tracking and Goodness of Fit Test for Defect Occurrence

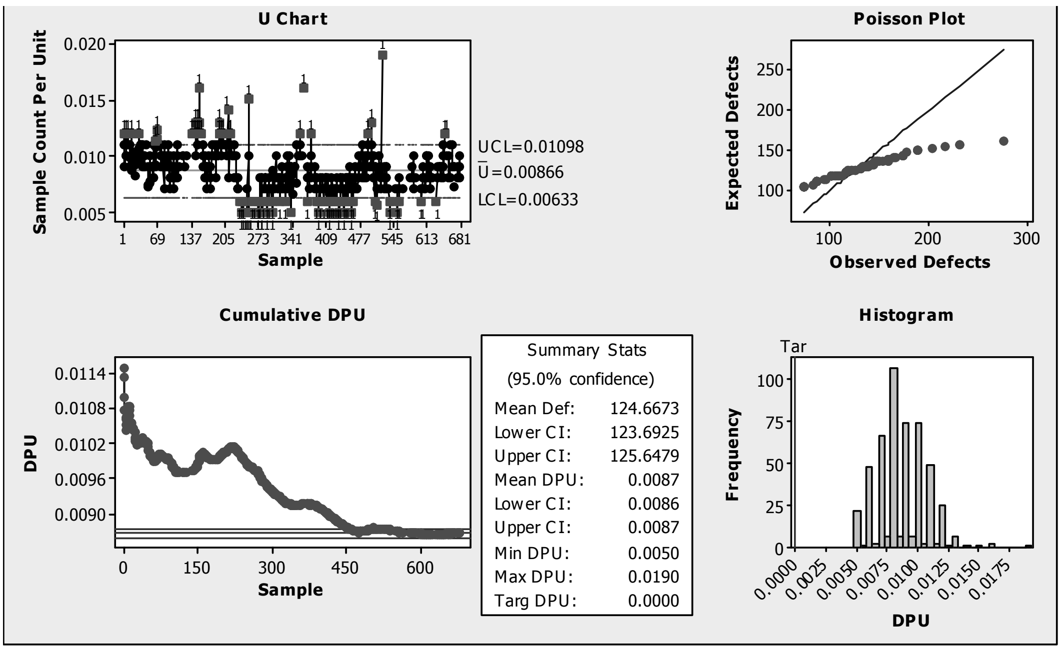
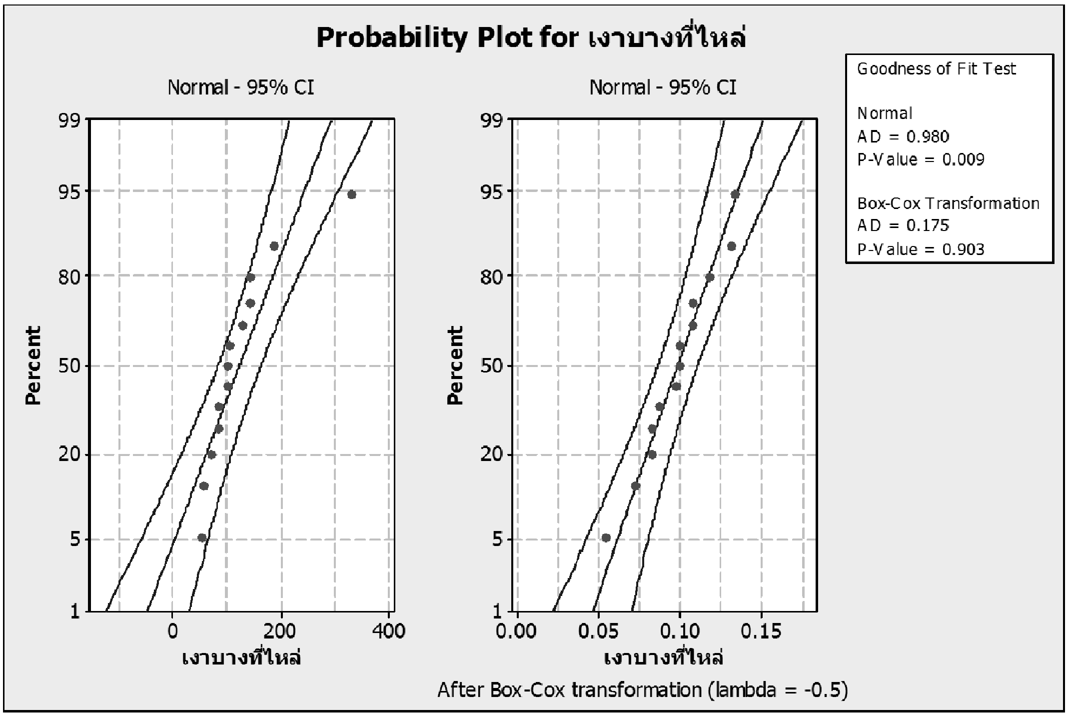


Figure 3: Box-Cox Transformation



As a result, the next step in making estimation of the defect occurrence is to estimate the average occurrence for a given period of time. Using central limit theorem and likelihood analysis (Greenwood, and Nikulin, 1996; Richard 2004), the average occurrence for each type of defects can be identified in normal distribution or Box-Cox normal transformation as shown in Equation (2).

$$\left[prob\ (\overline{defect}_i \geq 1\%)\ |\ prob\_of\_occurance\ (defect_i) * Time \right] \quad (2)$$

4. RESULTS AND CONCLUSION

In order to validate the proposed workload estimation method, the observations for a same time period and same type of product was conducted. Then, using a time study method (Work sampling) to estimate the workload of operator in doing all correction method. As shown in Figure 4, the results from both method is very close (8.807 for proposed method and 8.184 for time study).

Figure 4: Comparison between proposed method and time study method

	Defect Analysis		Time Study	
Working Time per Hour	**Operator**	**Asst. Operator**	**Operator**	**Asst. Operator**
Routine Time (min)	15.691	15.691	15.691	15.691
Allowance for Routine (min)	5.527	5.527	5.527	5.527
Total Routine Time (min)	21.218	21.218	21.218	21.218
% Working Time for Routine	35.36	35.36	35.36	35.36
Correction Time (min)	8.807	4.578	8.184	8.184
Allowance for Correction (min)	3.217	1.780	2.912	2.912
Total Correction Time (min)	12.025	6.358	11.095	11.095
% Working Time for Correction	20.04	10.60	18.49	18.49
Total Time (min)	33.243	27.576	32.314	32.314
% Working Time (min)	55.41	45.96	53.86	53.86
Number of Workers	0.554	0.460	0.539	0.539

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