

Implementation Of Exponentially Weighted Moving Average Control Chart On Demerit Data For Industry

Alfi Nurkhauly^{a*}, Georgina Maria Tinungki^{a**}, Erna Tri Herdiani^{a**}

* Corresponding Author: alfinurkhauly261297@gmail.com

**Corresponding Author: georgina@unhas.ac.id

***ernatriherdiani@unhas.ac.id

Department of Statistics, Faculty of Mathematics and Natural Sciences, Hasanuddin University, Makassar, 90245 Indonesia Makassar, Indonesia

Abstract

In general, attribute control charts use p, np, and u control charts when the data involved consists of two attributes. But when the attribute is more than one, the demerit control chart is present to overcome this problem. The assumption that must be met in this control chart is that the relationship between one sample and another is independent. In fact, this assumption is often not met, so that the correlation between one sample and another must be considered. One application of this case is in the industrial world, especially at PT Unitex Tbk on the New Ajl Dobby machine. In this paper, we will discuss the application of the Demerit control chart used to test the quality of the production process if in a process the number of defects each unit between observations is correlated from time to time. Then an effort is needed to obtain another control chart that is more suitable for the data, the control chart, which is appropriate and will be proposed in this paper, namely the Exponentially Weighted Moving Average (EWMA) control chart on demerit data. Merging the two graphs aims to increase the sensitivity of the control chart in detecting out of control. The results show that the EWMA - Demerit control chart will be more sensitive than the demerit control chart when the value is $0,1 \leq \lambda \leq 0,6$.

Keywords: Control Chart, Demerit system, Autocorrelation, Exponentially Weighted Moving Average

1. INTRODUCTION

Lack of quality of a product can be caused by human error, machine error, machine maintenance, up to product storage. Lack of quality is one of the considerations for consumers to buy goods or use services. Thus the assessment is very important for producers so as not to lose their consumers. Industrial development is increasing rapidly, demanding competition between industries to produce the best quality products. Good product quality is obtained if the production process goes well too. Therefore, it is necessary to control the production process by monitoring the quality of the production process whether it is running well or not (Agmalaro, 2010).

Quality control has an important role in a good production process that will produce good products. Product quality control, improvement, and monitoring of the production process are carried out using a tool called a control chart. Control charts can be classified into two general types. If the quality characteristics can be measured and expressed in numbers, this is usually called a variable control chart, while quality characteristics that cannot be measured on a quantitative scale are called control charts (attributes). Attribute control charts are usually used for defective and non-defective data. The control chart is a p-chart, c-chart or u-chart. In more defective products, more than two categories, (Chen 2005). Introducing the Demerit control chart for monitoring the total weight of the number of defects in each category. An explanation of this Demerit control chart can also be included in (Montgomery, 2001). The classic Demerit control chart assumes that the classification is in the same category. This control chart is determined subjectively. Quality control according to the Demerit control chart or the classical Demerit control chart (CDCC) (Agus et al, 2019).

The demerit control chart is used to test the quality of the production process by knowing the number of defects per one product unit as a sample, with varying unit sizes. The number of defects per unit is mutually independent between one observation time and another. In this case a problem will arise, what if in a process it gives the number of defects per unit between observations that are correlated from time to time, which is commonly called time series data. (Misbakhul Choeroni, 2013). Then an effort is needed to obtain another control chart that is more suitable for the data, a control chart that is in accordance with the above problems, namely the Exponentially Weighted Moving Average (EWMA) control chart that can handle data on the number of defects per inspection unit between observations which are correlated with time. to time. The Exponentially Weighted Moving Average (EWMA) control chart is an alternative used in controlling shifts in value in a process, the EWMA control chart will monitor shifts in the average value. (Dewiantari et al, 2019). This research will discuss the application of the Demerit and EWMA-Demerit control charts in controlling PT. Unitex Tbk. Then from the two control charts, the Demerit and EWMA-Demerit control charts, a comparison of process decision results will be carried out to find out which control chart has better sensitivity.

2. RESEARCH

2.1 Demerit Control Chart

For example x_A , x_B , x_C , and x_D states the number of defective products in the class A, B, C, and D successively, from a number of samples n . It is assumed that each class is independent and modeled based on the Poisson distribution with the expected value of the number of defects respectively λ_A , λ_B , λ_C , and λ_D when the process is in control. For example w_A , w_B , w_C , and w_D is the weight of each class of defective products respectively. . The number of demerits n samples is defined as:

$$d = w_A \cdot x_A + w_B \cdot x_B + w_C \cdot x_C + w_D \cdot x_D \quad (1)$$

Following are several types of disability levels categorized into several classes according to the importance of the disability (Ramadhani et al., 2014). The general pattern of product defects based on the weight of the defects can be given, namely class A defects (Very Serious), class B defects (Serious), class C defects (Moderately Serious), D defects (Minor) (Montgomery, 2009). Where:

w_A is the weight of the disability in the category A

w_B is the weight of the disability in the category B

w_C is the weight of the disability in the category C

w_D is the weight of the disability in the category D

In general, the weight is determined as follows $w_A = 100$, $w_B = 50$, $w_C = 10$, and $w_D = 1$. After that, proceed with calculating the statistics proposed by Jones et al (1999) stating the number of demerits each unit:

$$u = \frac{d}{n} \quad (2)$$

To monitor the quality of a product, d is defined as (1) and n , is the number of observations in each sample. The control chart for the statistic demerit is:

$$\text{Upper Control Limit (UCL)} = \bar{u} + 3 \sigma_u$$

$$\text{Center Line} = \bar{u}$$

$$\text{Lower Control Limit (LCL)} = \bar{u} - 3 \sigma_u$$

With

$$\bar{u} = \frac{\sum_{i=1}^N u_i}{N}$$

$$\sigma_u^2 = \frac{1}{N-1} \sum_{i=1}^N (u_i - \bar{u})^2$$

2.2 Exponentially Weighted Moving Average Control Chart

The EWMA control chart is a control chart that is used to monitor attribute data and EWMA variable data defined as follows (Nelwati et al, 2019):

$$z_i = \lambda X_i + (1 - \lambda) z_{i-1}$$

When $0 < \lambda \leq 1$ is the weight parameter. In general, the value of λ in intervals $0,05 \leq \lambda \leq 0,25$ works fine in practice, with $\lambda = 0,05$, $\lambda = 0,10$ and $\lambda = 0,20$ become a popular choice (Montgomery, 2005).

X_i is the value of the observation to- i , with $i = 1, 2, 3, \dots, n$ is the time or subgroup of observations Y_0 is the initial value or the expected value of the production results. Sometimes value Y_0 can be derived from the average value of the observations, that is $Y_0 = \bar{X}$

If observation X_i is an independent random variable with variance σ^2 , then the variance of Y_i is:

$$\sigma_{Y_i}^2 = \sigma^2 \left(\frac{\lambda}{2-\lambda} \right) [1 - (1-\lambda)^{2i}] \quad (3)$$

The centerline and control limits of the EWMA diagram are as follows :

$$UCL = Y_0 + L \sigma \sqrt{\frac{\lambda}{2-\lambda}} [1 - (1-\lambda)^{2i}]$$

$$CL = Y_0$$

$$LCL = Y_0 - L\sigma\sqrt{\frac{\lambda}{2-\lambda}} [1 - (1-\lambda)^{2i}]$$

if $i = 1, 2, 3, \dots, n$ approaches infinity, then the control limit will approach a state of equilibrium so that the control chart will become

$$UCL = Y_0 + L\sigma\sqrt{\frac{\lambda}{2-\lambda}}$$

$$CL = Y_0$$

$$LCL = Y_0 - L\sigma\sqrt{\frac{\lambda}{2-\lambda}}$$

2.3 Average Run Length

One way to measure the performance of the control chart is to use the Average Run Length (ARL). ARL is the number of averages or samples required before a point or sample indicates an uncontrollable state. If the process is in control then it is used ARL_0 , so that ARL_0 will have a larger value whereas ARL_1 would be worth less under the circumstances out of control (Montgomery, 2009).

The ARL value is divided into two, namely when the condition is in control and when it is out of control, each of which is shown in the following equation

$$ARL_0 = \frac{1}{\Pr(\text{reject } H_0 | H_0 \text{ correct})} = \frac{1}{\alpha} \quad (2.13)$$

$$ARL_1 = \frac{1}{\Pr(\text{accept } H_0 | H_0 \text{ wrong})} = \frac{1}{1-\beta} \quad (2.14)$$

2.4 Exponentially Weighted Moving Average-Demerit Control Demerit

For example x_i is time series data and λ be a weighting factor whose value is between 0 and 1. Mark exponentially weight moving average (EWMA) defined as follows (Nelwati et al., ..., 2019):

$$Z_i = \lambda X_i + (1-\lambda)Z_{i-1}$$

if U_i is the average value of defects per inspection unit for each subgroup of observations totaling n subgroup. Then the EWMA value for Demerit data is:

$$Y_i = \lambda U_i + (1-\lambda)Y_{i-1}; i = 1, 2, \dots, n \quad (4)$$

where λ is the weighted parameter with $0 < \lambda < 1$ a constant and an initial value (required with the first sample for $i = 1$, with $U = \bar{U}$; $i = 1, 2, \dots, n$ is the observed value ke- i , when $i = 1$ so $Y_{i-1} = Y_{1-1} = Y_0$ when Y_0 is the initial value used to obtain the EWMA value in the first sample. Mark Y_0 is the average value of the observations is (Montgomery, 1990):

$$Y_0 = \bar{U} = \frac{\sum_{i=1}^n U_i}{n} \quad (5)$$

By describing equation (2.8) is obtained

For $i = 1$, then

$$Y_1 = \lambda U_1 + (1-\lambda)Y_{1-1},$$

$$= \lambda U_1 + (1-\lambda)\bar{U}$$

For $i = 2$, then

$$Y_2 = \lambda U_2 + (1-\lambda)Y_{2-1},$$

$$= \lambda U_2 + \lambda(1-\lambda)U_1 + (1-\lambda)^2\bar{U}$$

For $i = 3$, then

$$Y_3 = \lambda U_3 + (1-\lambda)Y_{3-1},$$

$$= \lambda U_3 + \lambda(1-\lambda)U_2 + \lambda(1-\lambda)^2U_1 + (1-\lambda)^3\bar{U}$$

Next for $i = 1, 2, 3, \dots, n$ can be generalized as follows:

$$Y_i = \lambda U_i + \lambda(1 - \lambda)U_{i-1} + \lambda(1 - \lambda)^2 U_{i-2} + \dots + \lambda(1 - \lambda)^{i-2} U_2 + \lambda(1 - \lambda)^{i-1} U_1 + (1 - \lambda)^i U \quad (6)$$

Equation (2.9) can be simplified to:

$$Y_i = \lambda \sum_{j=0}^{i-1} (1 - \lambda)^j U_{i-j} + (1 - \lambda)^i U \quad (7)$$

Based on the description above, it can be seen that there is an average movement for each i . In addition, in equation (4.3) it can be seen that the weight decreases exponentially from the previous subgroup average to the newest subgroup average, that is $\lambda(1 - \lambda)^0, \lambda(1 - \lambda)^1, \lambda(1 - \lambda)^2, \dots, \lambda(1 - \lambda)^{i-2}, \lambda(1 - \lambda)^{i-1}$. For Y_i there are moving averages and weights that experience exponential changes, so Y_i is called the exponential weight moving average (EWMA). Montgomery (2009) mentions that EWMA has a mean and variance. The mean value of the EWMA control chart is the result of the expectation Y_i with the expected mean value being the value of Y_0 . Based on equation (4.4) the mean of Y_i , that is:

$$\begin{aligned} E[Y_i] &= E \left[\lambda \sum_{j=0}^{i-1} (1 - \lambda)^j U_{i-j} + (1 - \lambda)^i Y_0 \right] \\ &= \lambda(E[U_i] + (1 - \lambda)^1 E[U_{i-1}] + (1 - \lambda)^2 E[U_{i-2}] + (1 - \lambda)^3 E[U_{i-3}] + \dots + E[(1 - \lambda)^{i-1} U_1] + (1 - \lambda)^i Y_0) \end{aligned} \quad (4.5)$$

For each sample, the expected value is the value Y_0 or mathematically mean for each sample i , with $i = 1, 2, 3, \dots, n$, so $E[U_i] = Y_0$. So obtained $E[U_1] = E[U_2] = \dots = E[U_1] = E[U_n] = \bar{U}$ Next to be:

$$\begin{aligned} E[Y_i] &= \lambda \{ \bar{U} + (1 - \lambda)^1 \bar{U} + (1 - \lambda)^2 \bar{U} + (1 - \lambda)^3 \bar{U} + \dots + (1 - \lambda)^{i-1} \bar{U} \} + (1 - \lambda)^i \bar{U} \\ &= \lambda \{ 1 + (1 - \lambda)^1 + (1 - \lambda)^2 + (1 - \lambda)^3 + \dots + (1 - \lambda)^{i-1} \} \bar{U} + (1 - \lambda)^i \bar{U} \end{aligned} \quad (4.6)$$

Ekspektasi $(1 + (1 - \lambda)^1 + (1 - \lambda)^2 + (1 - \lambda)^3 + \dots + (1 - \lambda)^{i-1})$ in equation (4.6) Form a geometric series with initial values $a = 1, r = (1 - \lambda)$, and $n = 1$ so obtained:

$$\begin{aligned} s_n &= \frac{a(1 - r^n)}{(1 - r)}, 0 < r < 1 \\ \sum_{j=0}^{i-1} (1 - \lambda)^j &= \frac{1(1 - (1 - \lambda)^i)}{1 - (1 - \lambda)} = \frac{1(1 - (1 - \lambda)^i)}{\lambda} \end{aligned} \quad (8)$$

Substituting equation (4.7) into equation (4.6), we get:

$$\begin{aligned} E[Y_i] &= \lambda \{ 1 + (1 - \lambda)^1 + (1 - \lambda)^2 + (1 - \lambda)^3 + \dots + (1 - \lambda)^{i-1} \} \bar{U} + (1 - \lambda)^i \bar{U} \\ &= \bar{U} \{ \lambda(1 + (1 - \lambda)^1 + (1 - \lambda)^2 + \dots + (1 - \lambda)^{i-1}) + (1 - \lambda)^i \} \end{aligned}$$

$E[Y_i] = \bar{U}$ which is the average value of the EWMA

Next is the variance value of EWMA

$$\begin{aligned} \sigma_{Y_i}^2 &= \text{var}(Y_i) \\ &= \text{var} \left(\lambda \sum_{j=0}^{i-1} (1 - \lambda)^j U_{i-j} + (1 - \lambda)^i Y_0 \right) \\ &= \text{var} \left(\lambda \sum_{j=0}^{i-1} (1 - \lambda)^j U_{i-j} \right) + \text{var}((1 - \lambda)^i Y_0) + 2 \text{cov} \left(\lambda \sum_{j=0}^{i-1} (1 - \lambda)^j U_{i-j}, (1 - \lambda)^i Y_0 \right) \end{aligned} \quad (9)$$

Since c is a constant then $\text{var}(C) = 0$ so that $\text{var}((1 - \lambda)^i Y_0) = 0$ and because every U_i assumed to be independent, then $\text{cov}(\lambda \sum_{j=0}^{i-1} (1 - \lambda)^j U_{i-j}, (1 - \lambda)^i Y_0) = 0$, so that equation (4.8) can be written as equation (4.9).

$$\sigma_{Y_i}^2 = \text{var} \left(\lambda \sum_{j=0}^{i-1} (1 - \lambda)^j U_{i-j} \right) + 0 + 2(0) = \lambda^2 \left(\sum_{j=0}^{i-1} (1 - \lambda)^{2j} \sigma_{U_i}^2 \right) \quad (10)$$

Equation (4.9) has expectations $\sum_{j=0}^{i-1} (1 - \lambda)^{2j}$ which is a geometric series with initial values $a = 1, r = (1 - \lambda)^2$ and $n = i$, then obtained

$$s_n = \frac{a(1 - r^n)}{(1 - r)} = \frac{1 - (1 - \lambda)^{2i}}{2\lambda - \lambda^2} \quad (11)$$

substituting into equation (4.10) into equation (4.9), we get:

$$\sigma_{Y_1}^2 = \lambda^2 \sum_{j=0}^{i-1} (1-\lambda)^{2j} \sigma_{U_1}^2 = \lambda \sigma_{U_1}^2 \left[\frac{1 - (1-\lambda)^{2i}}{2-\lambda} \right]$$

If exemplified $\sigma_{U_1}^2 = \sigma^2$ then the variance of EWMA is as follows:

$$\sigma_{Y_1}^2 = \frac{\lambda \sigma^2 (1 - (1-\lambda)^{2i})}{2-\lambda} \quad (12)$$

The control limits of the EWMA loss control chart are UCL and LCL as follows:

$$\begin{aligned} UCL &= \bar{U} + L \sigma_{Y_i} = \bar{U} + L \sigma \sqrt{\frac{\lambda(1-(1-\lambda)^{2i})}{2-\lambda}} \\ CL &= \bar{U} \\ LCL &= \bar{U} - L \sigma_{Y_i} = \bar{U} - L \sigma \sqrt{\frac{\lambda(1-(1-\lambda)^{2i})}{2-\lambda}} \end{aligned}$$

If $i = 1, 2, 3, \dots, n$ approaches infinity, then the value $(1-\lambda)^{2i}$ close to zero, so the value of the variance $\sigma_{Y_i}^2$ to the limit value

$$\sigma_{Y_i}^2 = \lim_{i \rightarrow \infty} \left[\frac{\lambda \sigma^2 (1 - (1-\lambda)^{2i})}{2-\lambda} \right] = \frac{\lambda \sigma^2}{2-\lambda} \lim_{i \rightarrow \infty} (1 - (1-\lambda)^{2i})$$

Noted that $0 < \lambda \leq 1 \Leftrightarrow -1 \leq -\lambda < 0 \Leftrightarrow 0 \leq 1-\lambda < 1$, so there's a $h \in \mathbb{Q}$ caused $1-\lambda = \frac{1}{h}$ then the equation becomes

$$\sigma_{Y_i}^2 = \frac{\lambda \sigma^2}{2-\lambda} \lim_{i \rightarrow \infty} \left(1 - \left(\frac{1}{h} \right)^{2i} \right) = \frac{\lambda \sigma^2}{2-\lambda}$$

Thus, the variance of Y_i , will be constant, that is $\frac{\lambda \sigma^2}{2-\lambda}$ then the control chart will be:

$$\begin{aligned} UCL &= \bar{U} + L \sigma \sqrt{\frac{\lambda}{2-\lambda}} \\ CL &= \bar{U} \\ LCL &= \bar{U} - L \sigma \sqrt{\frac{\lambda}{2-\lambda}} \end{aligned}$$

2.5 Case Study

The data used in this paper is secondary data obtained from data on fabric production defects from PT. Unitex Tbk in the weaving section based on monthly inspections from January to December 2018. Data on fabric product defects. There are 4 variables used in this study which show data with different sample sizes taken from January to December 2018 on defects in the production of weaving. Furthermore, this data will be processed using several process control statistical methods including demerit control charts, ewma control charts and ewma demerit control charts..

3. Method

3.1 Data Sources and Research Variabels

The data used in this study is secondary data obtained from data on fabric production defects from PT. Unitex Tbk in the weaving section based on monthly inspections starting January-December 2018. There are 4 variables used in this study which show data with different sample sizes taken from January-December in 2018 on defects in the production of the weaving section.

3.2 Analysis Step

The following steps were taken in response to the research objectives:

1. Apply the Demerit control chart to data on the number of defects in fabric production.
2. Eliminate uncontrolled data until everything is within control limits for monitoring

3. Applying an exponentially weight moving average (EWMA) control chart on fabric defects data.
4. The control chart for EWMA-demerit with variations $\lambda = 0.1, \lambda = 0.2, \lambda = 0.3, \lambda = 0.4, \lambda = 0.5, \lambda = 0.6, \lambda = 0.7, \lambda = 0.8, \lambda = 0.9$ and $L = 3$.
5. Calculating the average run length (ARL) value of the Demerit control chart and control chart (EWMA) then comparing the performance of the two control charts in monitoring the mean shift in the cloth production process based on the ARL value that has been obtained

4. RESULTS

4.1 Demerit Control Chart

The Demerit control chart is used when the type of defect is categorized into several classes of defects based on the severity of the defects. Defects in the fabric production of PT Unitex Tbk can be sorted based on the severity of the defects. Class 1 defects are the type of defect that causes the most severe damage, then class 2, class 3, and class 4 defects. Using the weighting values explained in the subchapter, the number of weighted defects can be calculated for each subgroup according to equation (1). Calculation of the number of weighted defects on the New Ajl Dobby machine can be seen in the following steps:

Table 1 Demerit Control Chart

Subgroup	Damaged	Hole	Connect ion	Remainin g Thread	Total Sampling	d	u = d/ni
1	0	0	0	0	3,780.00	-	-
2	0	0	120	0	3,150.00	1,200.00	0.38
3	120	0	0	0	3,840.00	12,000.00	3.13
4	60	0	0	0	3,540.00	6,000.00	1.69
5	0	0	0	0	3,120.00	-	-
6	0	0	120	0	4,290.00	1,200.00	0.28
7	0	0	0	0	3,360.00	-	-
8	0	0	0	0	3,690.00	-	-
9	240	0	0	0	4,020.00	24,000.00	5.97
10	120	0	0	0	3,390.00	12,000.00	3.54
11	240	120	0	0	4,500.00	30,000.00	6.67
12	180	0	0	0	3,450.00	18,000.00	5.22
13	60	0	0	0	3,570.00	6,000.00	1.68
14	0	0	0	120	1,890.00	120.00	0.06
15	0	0	0	0	1,680.00	-	-
16	0	0	0	0	1,470.00	-	-
17	0	0	0	0	2,070.00	-	-
18	0	0	120	0	1,830.00	1,200.00	0.66
19	120	0	0	0	1,860.00	12,000.00	6.45
20	180	0	0	0	1,260.00	18,000.00	14.29
.							
.							
.							
197	120	0	0	0	3,060.00	12,000.00	3.92
198	60	0	0	0	3,150.00	6,000.00	1.90
199	120	0	0	0	2,910.00	12,000.00	4.12

200	240	0	0	0	2,220.00	24,000.00	10.81
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The mean of class A = 45.3, class B = 16.9, class C = 18 and class D = 3. The overall average of the demerit statistics is 2.06 and the standard deviation is 3.17. Thus, the demerit control map to be obtained by UCL, CL and LCL is as follows:

$$UCL = 2.06 + 3(3.17) = 11.57$$

$$CL = 2.06$$

$$LCL = 2.06 - 3(3.17) = 7.45$$

These values are used to form a demerit control chart for the New Ajl Dobby engine as shown in Figure 1

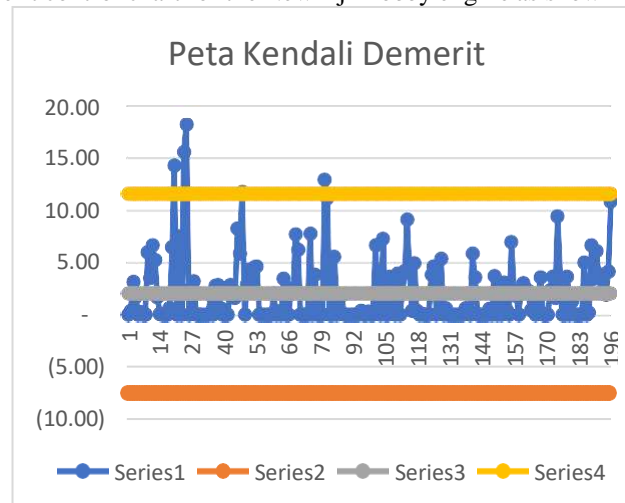


Figure 1. Demerit Control Chart

Figure 1 shows 5 observation points that are outside the control limits, namely subgroup data 20, 24, 25, 48, and 82 of the 200 preliminary sample data, as many as 195 samples are within the control limits. Furthermore, control limits will be determined so that all preliminary data are within the control limits. By taking the value $\alpha = 0.0027$. Furthermore, the control chart will be investigated if the five data that are outside the control limits are removed, the results are as follows:

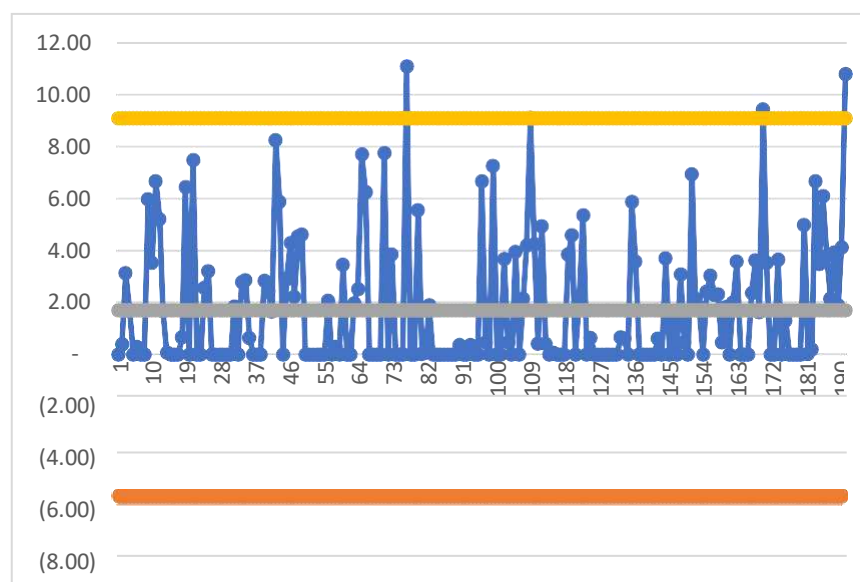


Figure 2. Demerit Control Chart after 5 Out of Limit Samples are Eliminated

After 5 samples of data that are outside the control limits are eliminated, a new demerit control chart is determined again and the results are as follows:

$$UCL = 1.70 + 3(2.46) = 9.09$$

$$CL = 1.70$$

$$LCL = 1.70 - 3(2.46) = 5.70$$

Figure 2 shows that there are still 3 out of the control limits, namely the 83rd, 78th and 200th data, thus a control chart will be made with preliminary data within the control limits. Furthermore, the control chart will be investigated if the three data that are outside the control limits are excluded, the results are as follows

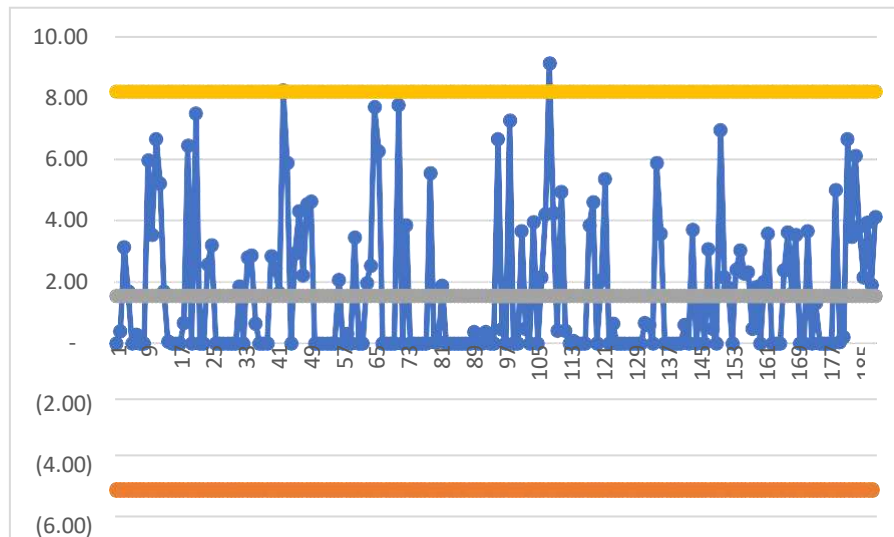


Figure 3. Peta Kendali Demerit dengan 8 Sampel yang berada diluar batas kendali dikeluarkan.

Setelah 3 sampel data yang berada diluar batas kendali dikeluarkan, maka dihitung peta kendali yang baru yaitu :

$$UCL = 1.54 + 3(2.23) = 8.22$$

$$CL = 1.54$$

$$LCL = 1.54 - 3(2.23) = 5.14$$

The results are based on Figure 3, there are still 2 that are outside the control limits, namely data 46 and 116, thus a control chart will be made with preliminary data that is within the control limits. Furthermore, the control chart will be investigated if the two data that are outside the control limits are excluded, the results are as follows

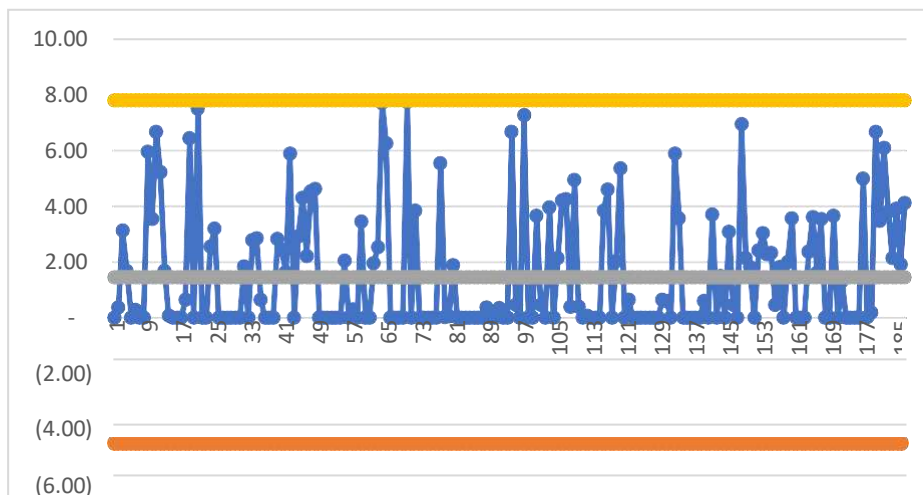


Figure 4. Demerit Control Chart without 10 Samples that are outside the control limits

After 2 samples of data that are outside the control limits are excluded, a new control chart is calculated, that is:

$$UCL = 1.45 + 3(2.11) = 7.80$$

$$CL = 1.45$$

$$LCL = 1.45 - 3(2.11) = 4.89$$

In Figure 4 it can be seen that all data is within the control limits after eliminating data that is outside the control limits, this process is carried out until 10 data are released, this control chart is used for monitoring.

4.2 Peta kendali EWMA-Demerit

Product quality control using the EWMA control chart is carried out when the data shift is small and the attribute data follows the Poisson distribution, while the value of the mean and standard deviation of u is as follows: $\bar{u} = \frac{\sum u_i}{n} = 2,06$ and with standard deviation $\sigma = 3,17$. Next, the transformation results will be determined using EWMA as in equation (4). The results are as follows:

Table 2 EWMA-Demerit Control Chart

Subgroup	Total Sampling	D	$u = d/ni$	Y_t
1	3,780.00	0.00	0.00	1.85
2	3,150.00	1200.00	0.38	2.89
3	3,840.00	12000.00	3.13	0.31
4	3,540.00	6000.00	1.69	0.17
5	3,120.00	0.00	0.00	0.00
6	4,290.00	1200.00	0.28	0.03
7	3,360.00	0.00	0.00	0.00
8	3,690.00	0.00	0.00	0.00
9	4,020.00	24000.00	5.97	0.60
10	3,390.00	12000.00	3.54	0.35
11	4,500.00	30000.00	6.67	2.07
12	3,450.00	18000.00	5.22	4.56
13	3,570.00	6000.00	1.68	2.98
14	1,890.00	120.00	0.06	3.84
15	1,680.00	0.00	0.00	0.00
16	1,470.00	0.00	0.00	6.21
17	2,070.00	0.00	0.00	0.00

18	1,830.00	1200.00	0.66	0.07
19	1,860.00	12000.00	6.45	0.68
20	1,260.00	18000.00	14.29	8.78
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192	4,500.00	30000.00	6.67	0.67
193	3,450.00	12000.00	3.48	0.35
194	3,930.00	24000.00	6.11	0.61
195	3,150.00	12000.00	3.81	0.38
196	3,360.00	7200.00	2.14	0.21
197	3,060.00	12000.00	3.92	0.39
198	3,150.00	6000.00	1.90	0.19
199	2,910.00	12000.00	4.12	0.41
200	2,220.00	24000.00	10.81	1.08

The control chart for EWMA demerit I EWMA with variations $\lambda = 0.1, \lambda = 0.2, \lambda = 0.3, \lambda = 0.4, \lambda = 0.5, \lambda = 0.6, \lambda = 0.7, \lambda = 0.8, \lambda = 0.9$ and $L = 3$. Are as follows:

Table 3 Demerit EWMA Control Chart Based on Value Changes λ

λ	LCL	CL	UCL	difference
0.10	0.02	2.06	4.10	4.08
0.20	- 0.91	2.06	5.03	5.93
0.30	- 1.68	2.06	5.80	7.48
0.40	- 2.39	2.06	6.51	8.90
0.50	- 3.08	2.06	7.20	10.28
0.60	- 3.77	2.06	7.89	11.65
0.70	- 4.47	2.06	8.59	13.06
0.80	- 5.21	2.06	9.33	14.54
0.90	- 5.99	2.06	10.11	16.10

Table 3 states that the greater the λ value, the wider the control limit of the Demerit EWMA Control Chart, this shows that the greater the λ value, the less sensitive it is to detect data out of control. When compared between the Demerit and EWMA Demerit control charts based on the width of the control chart, it can be concluded that the EWMA –Demerit control chart is more effective when the value $\lambda = 0,1 \dots 0,6$ while for $\lambda = 0,7 - 0,9$ it is better to use the Demerit control chart. Demeritcontrol.

5. CONCLUSIONS

Based on the analysis and discussion of the results of the research that has been done, it is concluded that Demerit's control chart on fabric production process data is $UCL = 4,89$, $CL = 1,45$, $LCL = 7,80$. The performance of the Exponentially weighted moving average control chart for Demerit data shows that it will be effective compared to the demerit control chart if the value is $0,1 \leq \lambda \leq 0,6$.

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