Production Quality Analysis by using System Modelling (Case Study of Tea Production Process at PTPN VI Solok)

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Abstract

Quality control is a key process in production activity that determines the outcome of it's product. One of the most important quality control activities is identifying the factors that cause rejected product. The system modeling states that production activities can be divided are input, processes and outputs that are interconnected with one another. This research was conducted at PTPN VI, a company that produces orthodox black tea. Production process starts from tea harvest, withered, leaves rolling, fermentation, drying, sorting, tester and packing. This research was conducted in the sorting process to analyze the cause of the low quality of tea leaves as measured by using water content parameters. The results show that the input of raw materials entering the sorting section is not in accordance to the company standards. Analysis of process quality using X and R control charts show that the process is uncontrolled. Thus causes the output of this stage is uncontrolled too

Keywords: tea, quality control, statistical process control, hypothesis testing;

1. Introduction

Quality or quality can be defined as a measure of how closely a good or service is conforming to specified standards. The specified standards can vary, depending on which party establishes them. So to get a good quality need to apply quality control starting from raw materials, production process, storage, material handling and distribution to consumers.

Quality control activities are technical and management activities to measure the characteristics of the quality of a good or service, then compare the measurement results with product specifications desired by the customer and take appropriate improvement measures if there is a discrepancy between actual and standard performance. Gasperz (2005) Quality control is a technique and operational activities used to meet the standard of quality expected. Based on the description above the quality control is a methodology of collecting and analyzing quality data, and determine and interpret measurement measurements that explain the process in an industrial system to improve product quality in order to meet customer needs and expectations.

PTPN VI is a company that produces black tea by orthodox that is processing of tea through all process start from receipt of wet leaf, down leaf, rolling, fermentation, drying, sorting and packing. Phase focusing on this research is the process of sorting is the process of separating / cleaning the powder of fiber (leather), stolok (leaf bone), and to get the size and color of tea particles are uniform in accordance with the standard of each type of quality desired consumer (Nazaruddin, 1993). The quality parameters to be analyzed in the production process are the moisture content, due to the mismatch of the moisture content in this process to the standards set by the firm

Problem solving by using a system approach is to look at the problem based on the components that make up it as well as the interactions between the components. In general the system is composed of 3 main components namely input, process and output. In this research, the sorting process is viewed as a smaller system that has input from the previous process and the output will be forwarded in the next stage

2. Method

Sorting process is the process of separating powder from fiber (leather), stolok (leaf bone), and to get the size and color of uniform tea particles. Process sorting with the system approach can be described as the Figure 1.

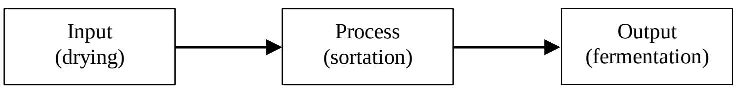

Fig 1. The System of Sortation Process

The process of quality control with system approach is to define work station sorting into 3 parts of the system namely:

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1. Input

The input of the sorting process is the output of the previous process, ie the drying process. The drying process is the process of reducing the moisture content from the initial conditions to the standard set by the company. The process of quality control at this stage is to prove whether the water content that has been completed from the drying process is in accordance with company standards.

Testing is done by using hypothesis test to prove that water content is in accordance with company standard. Statistically can be written as follows:

Ho : $\mu = \mu_0$
H1 : $\mu > \mu_0$ and H1 : $\mu < \mu_0$
Ho is null hypotheses while H1 is the alternative hypotheses .

$$z_{\text{observe}} = \frac{\bar{x}-\mu}{\sigma / \sqrt{n}} \quad (1)$$

Where : z = z observe
$\bar{x}$ = mean
μ_0 = parameter
σ = standard deviation
n = total amount of sample

2. Process

To determine that the sorting process is controlled X control chart and R control chart used to ensure the process are controlled statistically .

a. $\bar{x}$ chart

1. Determine $\bar{\bar{X}}$.

$$\bar{\bar{x}} = \frac{\sum_{i=1}^{g} \bar{x}i}{g} \quad (2)$$

Where: $\bar{\bar{X}}$ = average of sub-group averages
X_i = average of sub-group i
g = number of subgroups

2. Determine the control limit for x chart

Upper Control Limit (UCL) $= \bar{\bar{X}} + A_2\bar{R}$
Lower Control Limit (LCL) $= \bar{\bar{X}} - A_2\bar{R}$
Where: A_2 = coofecient value
R = gap of Xmaks dan Xmin

3. Plotting the x chart.

b. *R-chart*

1. Determine the average of range

$$\bar{R} = \frac{\sum_{i=1}^{g} Ri}{g} \quad (3)$$

Where: $\bar{R}$ = average of subgroup's range
R_i = subgroup' range i
g = number of subgroup

2.Determine the control limit for R chart

Upper Control Limit (UCL) $= D_4.\bar{R}$
Lower Control Limit (LCL) $= D_3.\bar{R}$
Wherw D_4 and D_3 is the coofecient value

3.Plotting the R chart

3. Output

Similar to input, the quality control process at the output is to ensure that the water content of the sorting process is in accordance with the standards set by the company. The method that will be used is to use hypothesis test of water content. More fully developed model can be seen in figure 2.

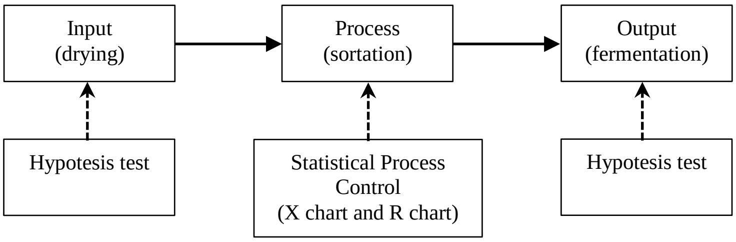

Fig 2. The Propose Model in Quality Control of Sortation Process

3. Results and Discussion

The data needed is data of water content conducted by observation directly at orthodox black tea production for 23 days starting from 8th February until 5th March 2017. From the data collected the standard deviation value obtained as follows;

Standard deviation $\sigma = \sqrt{\frac{\sum(xi-x)^2}{N-1}}$

$= \sqrt{\frac{11.55}{115-1}}$

$= 0.32$

a. Hypothesis test for input
   For $\alpha = 0.05$
   $H_0 : \mu = 2.5\%$
   $H_1 : \mu > 2.5\%$ and $H_1 : \mu < 3.0\%$
   so, $z_{(\alpha/2)} = z_{(0.05/2)}$
   $= 0.025$
   From the table, $z_{table} = 1.96$

   To find the value of z observe, calculate the z observe for company standard in 2.5% - 3.0%
   1. z observe for the water content standard in 2.5%
      $z_{observe} = \frac{\bar{x}-\mu}{\sigma / \sqrt{n}}$
      $= \frac{2.52-2.5}{0.32/\sqrt{115}}$
      $= 0.69$
      Because of $z_{observe} < z_{table}$ $(0,69 < 1,96)$ so, H_0 accepted

   2. z observe for the water content standard in 3.0%
      $z_{observe} = \frac{\bar{x}-\mu}{\sigma / \sqrt{n}}$
      $= \frac{2.52-3.0}{0.32/\sqrt{115}}$
      $= -16.55$
      Because of $z_{observe} < z_{table}$ $(-16.55 < -1.96)$ so, H_0 rejected

Based on the calculation obtained above can be concluded that the average of water content of the sample compared to the company standard in 2.5% - 3.0% the average water content of black tea from the drying stations not in accordance.

b. Quality control at the process using Statistical Process Control (SPC)
   1. X control chart
   To create x control chart, the steps are
   - Calculate the $\bar{\bar{X}}$
     $\bar{\bar{x}} = \frac{\sum_{i=1}^{g} \bar{x}i}{g}$
     $= \frac{80.8}{23}$
     $= 3.5$
   - Calculate the control limit for X chart

     Upper Control Limit (UCL) $= \bar{\bar{X}} + A_2\bar{R}$
     $= 3.5 + 0.419 \times 1.2$
     $= 4.00$
     Lower Control Limit (LCL) $= \bar{\bar{X}} - A_2\bar{R}$
     $= 3.5 - 0.419 \times 1.2$
     $= 3.03$
   - Plotting the X chart graph (as seen in Figure 3)

   2. R control chart
      To create R control chart, the steps are
      - Calculate the average of range

$$\bar{R} = \frac{\sum_{i=1}^{g} Ri}{g}$$
$$= \frac{26.5}{23}$$
$$= 1.2$$

- Calculate the control limit for R chart

  Upper Control Limit (UCL) $= D_4 . \bar{R}$
  $= 1.924 \times 1.2$
  $= 2.22$

  Lower Control Limit (LCL) $= D_3 . \bar{R}$
  $= 0.076 \times 1.2$
  $= 0.09$
- Plotting the R chart graph (as seen in Figure 3)

From the calculation of X and R chart can be illustrated control chart of X and R as seen at Figure 3:

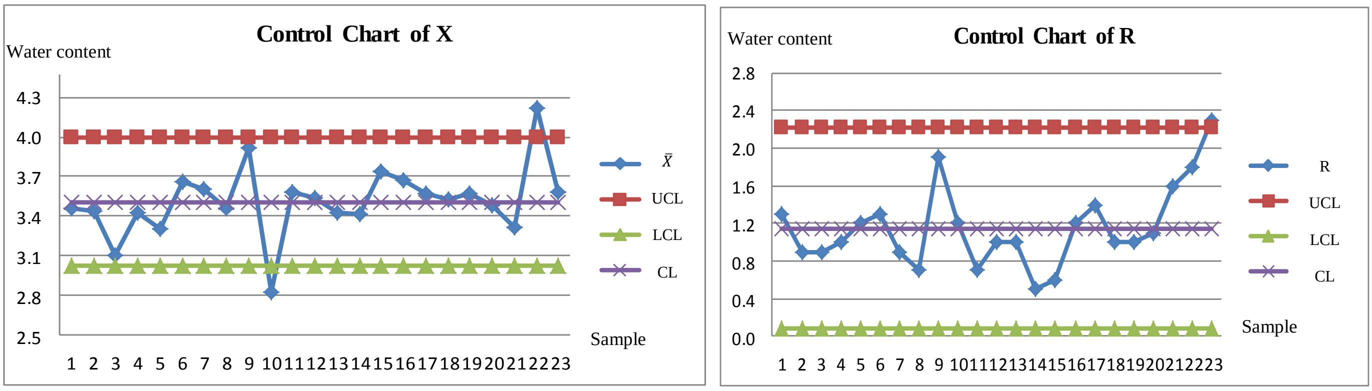

Fig 3. Control Chart of X and R

Note : The value of A_2 = 0.419, D_3= 0.076 dan D_4 = 1.924 for sub group sizes are 7 obtained from A and D table that indicate the factor of control charts.

As shown at Figure 3, the control chart of X shows 2 points of X (the average of water content sample) pass the control limit (out of control) at point 10 and 22 that indicated the sorting process is not statistically controlled. While, the control chart of R shows that there is 1 range that passes the control limit (out of control) point 23, this indicates that the control chart R also not controlled statistically. Thus, it can be concluded that from X and R control charts on the sorting process are not controlled statistically.

c. Hypothesis test for output

For $\alpha = 0.05$

$H_0 : \mu = 3.0\%$

$H_1 : \mu > 3.0\%$ and $H_1 : \mu < 4.0\%$

so, $z_{(\propto/2)} = z_{(0.05/2)}$
$= 0.025$

From the table, $z_{table} = 1.96$

To find the value of z observe, calculate the z observe for company standard in 3.0% - 4.0%

1. z observe for the water content standard in 3.0%

$$z_{observe} = \frac{\bar{x}-\mu}{\sigma / \sqrt{n}}$$
$$= \frac{3.51-3.0}{0.32/\sqrt{161}}$$
$$= 15.45$$

Because of $z_{observe} > z_{teble}$ (15.45 < 1.96) so, H_0 rejected

2. z observe for the water content standard in 4.0%

$$z_{observe} = \frac{\bar{x}-\mu}{\sigma / \sqrt{n}}$$
$$= \frac{3.51-4}{0,42/\sqrt{161}}$$
$$= -14.48$$

Because of $z_{observe} < z_{table}$ (−14.48 < - 1,96) so, H_0 rejected

Based on the calculation obtained above can be concluded that the average of water content of the sample compared to the company standard in 3.0% - 4.0% the average water content of black tea from the sorting stations not in accordance.

4. Conclusion

Based on calculation of input at drying process using test of hypothesis of average of water content finding the H_0 denied meanwhile of water content of black tea at drying station not in accordance with standard specified by company. While the process on the sorting station using the control chart found that the X and R chart are not controlled because there are measurement data that are out of control and the resulting output using the calculation of the test hypothesis z finding the H_0 rejected means the average rate black tea water content at a sorting station does not conform to the standards set by the company.

References

[1] Ariani, D. Wahyu, 2005. Statistical Quality Control (Quantitative Approach in Quality Management), Andy Offset, Yogyakarta.
[2] Arifin, S. 1994. Technical Guidelines for Tea and Quinine Processing. Research Center for Tea and Quinine. Gambung, Bandung.
[3] Ariani, Dorothea Wahyu. 2004. Statistical Quality Control. Andi Publisher. Yogyakarta.
[4] Fauzy, Akhmad. 2008. Industrial Statistics. Erlangga. Yogyakarta.
[5] Gaspersz, Vincent. 2005. Total Quality Management. PT Gramedia Pustaka Utama, Jakarta.
[6] Nazaruddin, and F. B. Paimin. 1993. Tea, Cultivation, and Processing. Penebar Swadaya. Jakarta.
[7] Montgomery, D. C. 1985. Introduction to Statistical Quality Control. Translation: Zanzawi, S. Yogyakarta: Gajah Mada University.
[8] Praptono. 1986. Book of Principal Material of Statistical Quality Control. Jakarta: Universitas Terbuka.
[9] Purnomo, Hari. 2004. Introduction to Industrial Engineering. Graha Ilmu, Yogyakarta.
[10] Riduwan, 2009. Introduction to Social Statistics. Alfabeta Publisher. Bandung