ATLANTIS PRESS
Advances in Economics, Business and Management Research, volume 72
12th International Conference on Business and Management Research (ICBMR 2018)

Filling Capability Analysis For Shampoo Production: A Case Study in the Manufacturing Industry

Miko Mei Irwanto, Humiras Hardi Purba
Master of Industrial Engineering Program
Mercu Buana University
Jakarta, Indonesia

Mohammad Hamsal
Management Department,
BINUS Business School Doctor of Research in Management
Bina Nusantara University
Jakarta, Indonesia

***Abstract*—In today's cosmetic market, shampoo is one consumer goods that is highly demanded. Its market competition is also very tough. In this situation, a shampoo manufacturing company should find a strategy to produce a high-quality product with good performance, less cost, and fewer losses. Thus, an improvement made must be straight to the point. To achieve that, accountability with hard data and evidence-based decision making is needed. Statistical Process Control provides accountability and is very essential in this quality–performance effort. A statistical process control chart allows us to see the capability of a process, whether a process is working correctly or not, whether the variation is natural or not, and what corrective action that we should take. To measure the capability, the terms Cp / Cpk is used. Cp is an indicator for process capability, while Cpk is an adjustment for Cp for the effect of non-centered distribution. In this paper, we will focus on improving the filling capability of a shampoo production process. A good filling capability is shown by Cp ¿ 1.67 and Cpk ¿ 1.67. Based on the study that has been done, it can be concluded that by having a good setting parameter, shut-off nozzle, flowmetric filling machine, proper size of hopper, and comprehensive training for operators, capability issue of the filling machine can be solved.**

***Index Terms*—Statistical Process Control, control chart, production, filling capability, shampoo, control parameters**

I. Introduction

Based on the Indonesian Commercial Newsletter, shampoo production growth is increasing every year by 2 [1]. With the rapid growth of the shampoo industry in Indonesia, competition in this field becomes very tight. Economic growth in the personal care industry it implorable for a company to implement a strategy so that its products always have a competitive advantage and win the market competition.

For that issue, quality and performance are two things that can not be separated. The company must make efforts to produce a high quality of products with an efficient way and very low rate of losses. To obtain this objective, it is necessary to control the quality management and engineering activities that can be measured and compare it with the specifications, and take appropriate improvement action if any deviation occurred. In response to these events, consumers now insist on high-quality shampoo, shampoo integrity, safety guarantees, and transparency. A manufacturing facility can ensure that these customers' needs are consistently met by performing frequent process capability analysis to determine how compliant their processes are.

One of the important processes in the shampoo industry is filling. In this study, we will observe and analyze the filling process of shampoo in a Personal Care company which filled in using a machine with a flow meter system. To analyze the filling capability, statistical process control method is used. By using this method, we will get the control chart, identify the problems happening during the filling process and define the improvement action to get a good capability of the filling machine (Cp $>$ 1.67 and Cpk $>$ 1.67).

II. Theories

A. Descriptive Statistics

The descriptive statistic is a statistic that is used to analyze data by describing the collected data without drawing a conclusion or generalization [2] . There are two numerical terms to describe the data. They are centralization and distribution. For centralization, the mean of the data is used, while for distribution, range and variants are used [3] .

B. Statistical Process Control

Statistical Process Control (SPC) is an analytical decision-making tool which can be used to monitor, control, analyze, manage, and improve a process by using statistic method. This method will generate a process control chart. Control charts are an essential tool for continuous quality control. It monitors and shows how a process is performing and how a process and capability are affected by the changes to the process. Control charts can also be used to determine the capability of the process. It helps to identify the special or assignable causes for factors that affect the performance. This information is then used to define the quality improvements. SPC has become not only a tool for analyzing quality improvements but as a method for assessing the capability of a process to repeatedly produce quality products. The capability of a process illustrates the ability to produce products within the given specification limits. During the manufacture of components, control charts are used to ensure non-conforming products are minimized. A

histogram is normally used to determine the spread of results within the specification range and the distribution of results around the nominal. When an assessment of the capability of a process is required, it is this spread that is commonly used to determine how capable a process is statistically an in-control process, which will be predominantly centered on the nominal. [4] Process capability acts as a Total Quality Management (TQM) tool and is described as a strategic management technique that plays a vital role in the company's operations management. The process capability study helps in designing the product, deciding the accepted norms, process and operators' selections in the operations management [5]. The evaluation of process capability is an important step in process quality improvement [6]. Besides control charts, another process capability indicator that is generated by statistical process control is Cp and Cpk. Cp is process capability, a simple and straightforward indicator of a process capability, while Cpk is the process capability index – adjustment of Cp for the effect of non-centered distribution. Cpk measures how close a process is running to its specification limits, relative to natural variability of a process. It also measures how close a process is to the target and how consistent it is around the average performance. In filling activities, a good process is interpreted by Cp ¿ 1.67 and Cpk ¿ 1.67. Some factors that affect the process capability of a filling process are the number of heads (nozzles), type of formula, and type of filling machine specification. To ensure that the study is representative, the minimum number of samples taken is 100 samples, with a minimum of 25 samples/nozzles in case of multi-nozzles [5]. Cp is calculated by

$$Cp = \frac{MaxTolerance - MinTolerance}{6 \times \sigma} \tag{1}$$

while Cpk is calculated by

$$Cpk = \min(\frac{\bar{X} - MinTolerance}{3 \times \sigma}, \frac{MaxTolerance - \bar{X}}{3 \times \sigma}) \tag{2}$$

with
$MaxTolerance$ =maximum filling volume allowed
$MinTolerance$ =minimum filling volume allowed
σ =standard deviation

Being in control of a manufacturing process using SPC is not enough. An "in-control" process can produce a bad or out-of-spec product. Manufacturing processes must meet or be able to achieve product specifications. Further, product specifications must be based on customers requirements. Process capability is the repeatability and consistency of a manufacturing process relative to the customer requirements in terms of specification limits of a product parameter. This measure is used to objectively measure the degree to which your process is or is not meeting the requirements. Capability indices have been developed to graphically portray that measure. Capability indices let you place the distribution of your process in relation to the product specification limits. Capability indices should be used to determine whether the process, given its natural variation, is capable of meeting established specifications. It is also a measure of the manufacturability of the product with the given processes. Capability indices can be used to compare the product/process matches and identify the poorest match (lowest capability). The poorest matches then can be targeted on a priority basis for improvement.

C. Shampoo

The shampoo is a cosmetic for hair and scalp cleanser of all kinds of dirt, whether in the form of oil, dust, dead cells, etc. The principal function of a shampoo is to clean/condition hair and leave it smelling pleasant. The typical shampoo consists mainly of water, a primary surfactant, one or more co-surfactants, and a soluble salt. Other ingredients are added for thickening, fragrance, preservation, and conditioning [6]. Normally, shampoo is used by mixing it in order to dissolve the natural oil released by the body to protect the hair and clean up the inherent dirt, increase the surface tension of the scalp, so it can shed the dirt [6].

III. Methods

A. Object of Study

In this study, the object of observation is the shampoo filling process in a personal care company in Indonesia. The authors took an observation in a filling machine which uses a flow meter system and has 6 nozzles (heads).

B. Methods of Observation

The steps that author used to conduct the study is as follows

1) Define the target, minimum tolerance, and maximum tolerance of the filling process.
2) Take the samples
   a) Take the tare data of by weighing the empty packaging (empty bottle, cap, front and back labels): @25 bottles/nozzle = 25 samples x 6 nozzles = 150 bottles
   b) Give a sign for the bottle order (nozzle order)
   c) Take the samples of the filled bottle @25 bottles/nozzle = 25 samples x 6 nozzles = 150 samples filled bottles within 30 minutes of a filling process without any stoppages (continuous filling)
   d) Subtract each samples data with the average tare to get the bulk weight
3) Calculate the Cp and Cpk data
4) Analyze the Cp and Cpk data, as well as the histogram
5) Define improvement actions
6) Re-taking the samples to see the impact of improvement actions
7) Draw conclusions

C. Data

1) Define the Specification: Format of shampoo during observation = 130mL
Density of shampoo = 1.02 gr/mL
The filling target = 132.6 gr

2) The Tare Data: The tare data is in table I and II (in gram)

TABLE I
TARE DATA FOR BOTTLE OF NOZZLE 1, 2, 3

No	Nozzle-1	Nozzle-2	Nozzle-3	No	Nozzle-1	Nozzle-2	Nozzle-3	No	Nozzle-1	Nozzle-2	Nozzle-3
1	18	18.1	16.7	10	16.3	16.5	15.9	18	16.8	16.2	16.2
2	16.5	18	18.1	11	18	16.1	16.5	19	16.4	18	16.3
3	16.9	18.1	16	12	16.6	16	16.1	20	15.7	16.4	15.9
4	16.3	18.1	16.3	13	16.7	15.7	16	21	16.3	15.9	16.2
5	16	16.6	16	14	15.5	18	16.4	22	16	18	18.2
6	16	16.1	16.1	15	17	16.5	16.1	23	16.5	18	16.6
7	15.9	15.7	16.5	16	18	18.2	16.6	24	15.9	16.7	16.2
8	16.5	15.6	16	17	16	15.8	16	25	16.5	15.9	16.1
9	16.9	16.4	16.7								

TABLE II
TARE DATA FOR BOTTLE OF NOZZLE 4, 5, 6

No	Nozzle-4	Nozzle-5	Nozzle - 6	No	Nozzle-4	Nozzle-5	Nozzle - 6	No	Nozzle-4	Nozzle-5	Nozzle - 6
1	16	16	15.9	10	16.5	16.5	15.9	18	16.5	15.9	16.1
2	18	15.4	16.2	11	16.2	16.4	18.1	19	15.9	16.2	18.1
3	16	16.2	16.6	12	16.2	16.8	16.2	20	16.1	15.7	16.3
4	17.9	18	16.6	13	16.1	16.6	16.6	21	18	16.2	18.2
5	16.1	16.2	16.1	14	16.6	16.3	16.1	22	16.3	16	18.2
6	16	18.1	16.5	15	16.3	16.1	16	23	16.5	15.8	18.1
7	16.2	16.6	16.2	16	16.8	15.8	16.2	24	15.9	18.2	16.3
8	16.3	16	16.5	17	16.2	16.6	16.3	25	15.9	18.2	16.5
9	16.4	16.2	16.6								

3) The data for each nozzle: The filling data of each nozzle is obtained by subtracting the brutt weight (bulk + empty packaging) with the tare of each bottle in section C.1. The filling data of each nozzle (in gram) are in Table III and IV

IV. ANALYSIS

A. Calculating the mean and standard deviation

1) Mean and standard deviation of whole data: See Table V

2) Mean and standard deviation per head: See Table VI

B. Calculating initial Cp and Cpk

From mean and standard deviation, we can calculate Cp and Cpk as follows Cp is calculated by

$$Cp = \frac{MaxTolerance - MinTolerance}{6 \times \sigma}$$
$$Cp = \frac{138.6 - 126.6}{6 \times 1.261} = 1.59$$

while Cpk is calculated by

$$Cpk = \min(\frac{\bar{X} - MinTolerance}{3 \times \sigma}, \frac{MaxTolerance - \bar{X}}{3 \times \sigma})$$
$$Cpk = \min(\frac{132.62 - 126.6}{3 \times 1.261}, \frac{138.6 - 132.62}{3 \times 1.261})$$
$$Cpk = \min(i.59, 1.58) = 1.58$$

Thus, the Cp = 1.59 and Cpk = 1.58.

From the calculation, it can be seen that the filling machine has not reached a good filling capability (standard: Cp = 1.67, Cpk = 1.67). This not good capability result also can be seen from the histogram below. From the histogram, it can be seen that the distribution of the data is too wide (interval = 6.01 gr), which implies the bad Cp. Moreover, the data is also not centered on the target filling, which implies the bad Cpk. For further analysis, we will calculate the Cp and Cpk per head, as follows.

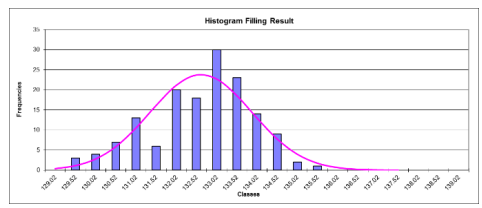


Fig. 1. Histogram of initial filling

Using equation (1) and (2), and the data in Table 6

Head 1

For Cp,

$$Cp = (138.6 - 126.6)/(6 \times 1.261) = 1.59$$

For Cpk,

$$Cpk = \min(\frac{132.49 - 126.6}{3 \times 1.319}, \frac{138.6 - 132.49}{3 \times 1.319})$$
$$Cpk = \min(1.48, 1.54) = 1.48$$

Head 2

For Cp,

$$Cp = \frac{138.6 - 126.6}{6 \times 1.129} = 1.77$$

For Cpk,

$$Cpk = \min(\frac{132.56 - 126.6}{3 \times 1.129}, \frac{138.6 - 132.56}{3 \times 1.129})$$
$$Cpk = \min(1.76, 1.78) = 1.76$$

TABLE III
FILLING DATA FOR BOTTLE OF NOZZLE 1, 2, 3

No	Nozzle-1	Nozzle-2	Nozzle-3	No	Nozzle-1	Nozzle-2	Nozzle-3	No	Nozzle-1	Nozzle-2	Nozzle-3
1.	133.50	129.44	132.60	9.	133.35	131.87	132.82	18.	132.76	132.70	131.59
2.	134.60	132.90	129.27	10.	133.20	132.43	132.94	19.	134.50	133.17	132.63
3.	132.88	133.23	132.38	11.	133.00	132.38	132.18	20.	129.85	132.60	132.20
4.	133.32	132.26	133.23	12.	131.25	132.21	133.65	21.	130.87	131.60	133.01
5.	132.04	134.30	132.00	13.	132.99	132.64	133.15	22.	132.68	132.93	132.11
6.	132.93	132.10	131.27	14.	131.84	132.89	130.20	23.	133.22	132.53	132.96
7.	133.56	134.79	133.25	15.	130.70	133.82	130.88	24.	130.54	132.97	133.06
8.	129.95	133.92	133.33	16.	132.90	130.96	133.21	25.	131.94	132.59	132.71
				17.	133.90	130.66	131.90				

Gross weight (the total weight) = net weight (the weight of the goods) + tare weight (the weight of the empty container) for nozzle 1,2 and 3.

TABLE IV
FILLING DATA FOR BOTTLE OF NOZZLE 4, 5, 6

No	Nozzle-4	Nozzle-5	Nozzle - 6	No	Nozzle-4	Nozzle-5	Nozzle - 6	No	Nozzle-4	Nozzle-5	Nozzle - 6
1.	130.90	132.30	133.92	9.	131.07	130.66	130.60	18.	130.90	132.63	133.60
2.	133.58	132.40	133.63	10.	130.91	130.56	129.63	19.	133.42	132.16	135.28
3.	132.87	133.50	134.67	11.	133.60	131.79	133.39	20.	134.02	131.40	130.97
4.	134.34	133.50	132.50	12.	134.55	132.82	134.12	21.	130.82	131.14	133.80
5.	134.02	133.75	135.08	13.	132.24	131.53	132.00	22.	131.92	133.00	134.70
6.	133.50	133.21	133.16	14.	132.00	132.91	131.40	23.	134.05	130.04	132.14
7.	132.63	133.98	131.21	15.	134.18	131.10	133.65	24.	133.50	133.67	134.58
8.	133.79	131.97	133.63	16.	133.30	133.61	133.99	25.	134.10	133.35	130.62
				17.	133.20	133.25	134.50				

Gross weight (the total weight) = net weight (the weight of the goods) + tare weight (the weight of the empty container) for nozzle 4, 5, and 6

TABLE V
MEAN AND STANDARD DEVIATION OF WHOLE DATA

Parameter	Value
Mean	132.62
Standard Deviation	1.261
Minimum	129.27
Maximum	135.28
Interval	6.01

TABLE VI
MEAN AND STANDARD DEVIATION PER HEAD

Head	Mean	Standard Deviation
Head 1	132.49	1.319
Head 2	132.56	1.129
Head 3	132.34	1.045
Head 4	132.94	1.234
Head 5	132.41	1.129
Head 6	133.07	1.581

Head 3
For Cp,

$$Cp = \frac{138.6 - 126.6}{6 \times 1.045} = 1.91$$

For Cpk,

$$\begin{aligned} Cpk &= \min\left(\frac{132.34 - 126.6}{3 \times 1.045}, \frac{138.6 - 132.34}{3 \times 1.045}\right) \\ Cpk &= \min(1.83, 1.99) = 1.83 \end{aligned}$$

Head 4 For Cp,

$$Cp = \frac{138.6 - 126.6}{6 \times 1.234} = 1.62$$

For Cpk,

$$\begin{aligned} Cpk &= \min\left(\frac{132.94 - 126.6}{3 \times 1.234}, \frac{138.6 - 132.94}{3 \times 1.234}\right) \\ Cpk &= \min(1.71, 1.53) = 1.53 \end{aligned}$$

Head 5 For Cp,

$$Cp = \frac{138.6 - 126.6}{6 \times 1.129} = 1.77$$

For Cpk,

$$\begin{aligned} Cpk &= \min\left(\frac{132.41 - 126.6}{3 \times 1.129}, \frac{138.6 - 132.41}{3 \times 1.129}\right) \\ Cpk &= \min(1.72, 1.82) = 1.72 \end{aligned}$$

Head 6 For Cp,

$$Cp = \frac{138.6 - 126.6}{6 \times 1.581} = 1.26$$

For Cpk,

$$\begin{aligned} Cpk &= \min\left(\frac{133.07 - 126.6}{3 \times 1.581}, \frac{138.6 - 133.07}{3 \times 1.581}\right) \\ Cpk &= \min(1.36, 1.16) = 1.16 \end{aligned}$$

To summarize, the Cp and Cpk for each head are as follows:

From this table, it can be concluded that filling at nozzle 2, 3, and 5 are already capable while filling at nozzle 1, 4, and 6 need to be improved.

TABLE VII
CP AND CPK PER HEAD

Head	Cp	Cpk
Head 1	1.52	1.48
Head 2	1.77	1.76
Head 3	1.91	1.83
Head 4	1.62	1.53
Head 5	1.77	1.72
Head 6	1.26	1.16

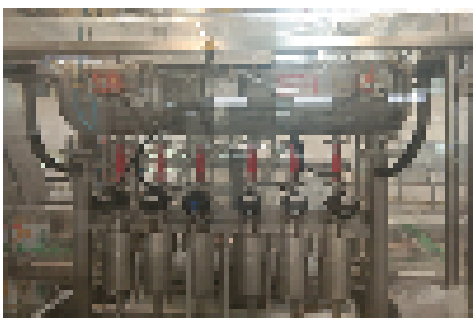
C. Improvement Action

To improve the capability, an analysis of the filling machine is done.

From a technical side, it is found that some causes triggering a less capable machine are:

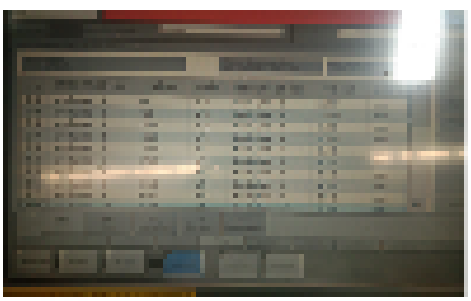
- Currently, the filling machine is using the non-shut-off nozzle.

- There is a flow rate issue at the bulk supply (especially during a filling non-viscous bulk)



Therefore, actions taken are as follows:

- Assess and re-define filler setting parameter



- Change nozzle type to shut-off
- Upgrade the size of hopper's pump (to reduce the flow rate issue)
- Conduct preventive maintenance once a month

D. Result after improvement

1) Filling result after improvement: The filling result after improvement can be seen in Table VIII and Table IX

2) Mean and standard deviation of whole data after improvement: See Table X

3) Mean and standard deviation of per head after improvement: See XI

4) Cp and Cpk after improvement: From data and equations, For Cp,

$$Cp = \frac{\max tolerance - \min tolerance}{6 \times \sigma}$$
$$Cp = \frac{138.6 - 126.6}{6 \times 0.399} = 5.01$$

For Cpk,

$$Cpk = \min\left(\frac{\bar{X} - \min tolerance}{3 \times \sigma}, \frac{\max tolerance - \bar{X}}{3 \times \sigma}\right)$$
$$Cpk = \min\left(\frac{132.52 - 126.6}{3 \times 0.399}, \frac{138.6 - 132.52}{3 \times 0.399}\right)$$
$$Cpk = \min(4.94,\ 5.08) = 4.94$$

From this calculation, it can be seen that the Cp and Cpk of the filling machine are already capable. This improvement can also be seen in the histogram below. From Fig. 2, it can

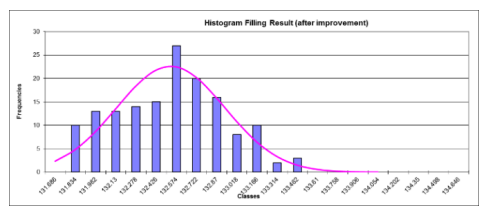


Fig. 2. Histogram of initial filling

be seen that the interval (distribution) of the data is narrower than before (interval of whole data changes from 6.01 gr to 1.77 gr), which implies a good Cp, Besides that, the data is now closer to the target, which implies a good Cpk.

To see the improvement for each nozzle, we can calculate Cp and Cpk per head.

Using equation (1) and (2), and the data in Table 11: <u>Head 1</u>
For Cp,

$$Cp = \frac{138.6 - 126.6}{6 \times 0.411} = 4.86$$

For Cpk,

$$Cpk = \min\left(\frac{132.63 - 126.6}{3 \times 0.411}, \frac{138.6 - 132.63}{3 \times 0.411}\right)$$
$$Cpk = \min(4.89\ ,\ 4.84) = 4.84$$

<u>Head 2</u>
For Cp,

$$Cp = \frac{138.6 - 126.6}{6 \times 0.350} = 5.71$$

For Cpk,

$$Cpk = \min\left(\frac{132.41 - 126.6}{3 \times 0.350}, \frac{138.6 - 132.41}{3 \times 0.350}\right)$$
$$Cpk = \min(5.53\ ,\ 5.89) = 5.53$$

TABLE VIII
FILLING DATA FOR BOTTLE OF NOZZLE 1, 2, 3 (AFTER IMPROVEMENT)

No	Nozzle-1	Nozzle-2	Nozzle - 3	No	Nozzle-1	Nozzle-2	Nozzle - 3	No	Nozzle-1	Nozzle-2	Nozzle - 3
1.	132.5	131.8	132.9	9.	133.45	131.98	132.75	18.	132.89	132.98	132.89
2.	132.6	132.4	132.45	10.	132.2	132.77	132.64	19.	133.15	132.74	132.01
3.	132.73	132.34	132.78	11.	132.9	131.85	132.47	20.	132.25	132.65	132.9
4.	132.3	132.47	132.39	12.	132.5	132.26	133.25	21.	132.75	131.9	132.04
5.	132.1	133.1	131.98	13.	132.8	132.6	132.96	22.	133.4	132.08	132.61
6.	132.8	132.35	132.61	14.	131.9	132.69	133.02	23.	133.18	132.26	131.98
7.	132.68	132.37	132.45	15.	132.17	132.28	132.94	24.	132.48	132.28	132.86
8.	131.97	132.62	132.03	16.	132.6	132.95	132.21	25.	132.74	132.16	132.19
				17.	132.8	132.4	132.4				

The filling result after improvement is shown

TABLE IX
FILLING DATA FOR BOTTLE OF NOZZLE 4, 5, 6 (AFTER IMPROVEMENT)

No	Nozzle-4	Nozzle-5	Nozzle - 6	No	Nozzle-4	Nozzle-5	Nozzle - 6	No	Nozzle-4	Nozzle-5	Nozzle - 6
1.	131.8	131.94	132.62	10.	132.61	133.53	131.92	18.	132.76	132.54	132.67
2.	132.2	132.23	132.51	11.	133.21	133.17	132.19	19.	132.31	132.75	132.63
3.	132.6	132.26	132.89	12.	132.45	132.82	132.52	20.	132.82	132.92	131.76
4.	132.47	132.64	132.7	13.	132.13	132.54	132.29	21.	132.65	133.08	131.94
5.	133.2	133.19	132.58	14.	131.99	132.37	132.61	22.	132.08	132.64	132.69
6.	131.9	132.79	133.19	15.	132.81	133.19	131.91	23.	132.5	132.28	131.76
7.	133.2	132.67	132.96	16.	132.7	133.25	132.14	24.	132.49	132.68	132.04
8.	132.59	132.53	132.17	17.	132.5	132.99	132.5	25.	132.18	132.81	132.54
9.	131.89	132.4	131.86								

The filling result after improvement is shown

TABLE X
MEAN AND STANDARD DEVIATION OF WHOLE DATA

Parameter	Value
Mean	132.62
Standard Deviation	1.261
Minimum	129.27
Maximum	135.28
Interval	6.01

TABLE XI
MEAN AND STANDARD DEVIATION OF WHOLE DATA

Head	Mean	Standard Deviation
Head 1	132.63	0.411
Head 2	132.41	0.350
Head 3	132.55	0.376
Head 4	132.48	0.401
Head 5	132.73	0.378
Head 6	132.38	0.395

Head 3

For Cp,

$$Cp = \frac{138.6 - 126.6}{6 \times 0.376} = 5.31$$

For Cpk,

$$\begin{aligned} Cpk &= \min\left(\frac{132.55 - 126.6}{3 \times 0.376}, \frac{138.6 - 132.55}{3 \times 0.376}\right) \\ Cpk &= \min(5.27, 5.36) = 5.27 \end{aligned}$$

Head 4

$$Cp = \frac{138.6 - 126.6}{6 \times 0.401} = 4.98$$

$$\begin{aligned} Cpk &= \min\left(\frac{132.48 - 126.6}{3 \times 0.401}, \frac{138.6 - 132.48}{3 \times 0.401}\right) \\ Cpk &= \min(4.88, 5.08) = 4.88 \end{aligned}$$

Head 5

$$Cp = \frac{138.6 - 126.6}{6 \times 0.378} = 5.29$$

$$\begin{aligned} Cpk &= \min\left(\frac{132.73 - 126.6}{3 \times 0.378}, \frac{138.6 - 132.73}{3 \times 0.378}\right) \\ Cpk &= \min(5.41, 5.17) = 5.17 \end{aligned}$$

Head 6

$$Cp = \frac{138.6 - 126.6}{6 \times 0.395} = 5.06$$

$$\begin{aligned} Cpk &= \min\left(\frac{132.38 - 126.6}{3 \times 0.395}, \frac{138.6 - 132.38}{3 \times 0.395}\right) \\ Cpk &= \min(4.87, 5.24) = 4.87 \end{aligned}$$

To summarize, the Cp and Cpk for each head are as follows

TABLE XII
MEAN AND STANDARD DEVIATION OF WHOLE DATA

Head	Cp	Cpk
Head 1	4.86	4.84
Head 2	5.71	5.53
Head 3	5.31	5.27
Head 4	4.98	4.88
Head 5	5.29	5.17
Head 6	5.06	4.87

From Table IV-D4, it can be seen that Cp and Cpk for nozzle 1,4,6 are already capable. Besides that, Cp and Cpk for other

nozzles are also improving, which means the improvement done is suitable for this filling process.

V. Conclusion

Based on the observation and filling result that has been conducted, it can be concluded that:

One of the ways to measure and improve the capability of the filling machine is by conducting capability study – calculating Cp and Cpk of the whole filling process. To improve the capability of filling machine, we can do further analysis by calculating Cp and Cpk for each nozzle. In this study, for the first trial, from 6 filling nozzles, 3 nozzles are not capable (1,4,6).

From the technical part, there are some factors affecting the capability of the machine: a good setting parameter, shut-off nozzle, flowmetric filling machine, proper size of hopper (for flow-rate adjustment). Besides the technical part, organization management in the filling line also has an important role in improving the performance and capability of the machine. To improve it, a comprehensive training skill matrix and operator qualification is a baseline for improving the operator's skills in doing the setting.

After improvement from the technical and organizational part, the Cp of Personal Care manufacturing filling machine increases from 1.59 to 5.06, while Cpk increases from 1.58 to 4.87. Therefore, the filling machine is now capable. To control the sustainability of the action, for daily monitoring, a volume check is conducted every 30 minutes during the filling process and a preventive maintenance must be implemented once a month.

References

[1] SWA Magazine, Indonesia 12/XXVII/9 June-22 June 2011.
[2] Sugiono, Qualitative-Quantitative Research Methods and R & D. Bandung: Alfabeta, 2010.
[3] M. G. Leitnaker et al., The Power of Statistical Thinking, 1st Edition. Massachusetts: Addison Wesley, 1996.
[4] https://www.isixsigma.com/tools-templates/capability-indices-process-capability/process-capability-cp-cpk-and-process-performance-pp-ppk-what-difference/, accessed on Sep 26th, 2017.
[5] https://knowledge.ulprospector.com/4431/pcc-shampoo-technology/, accessed on May 6th , 2018.
[6] JJ Dahlgaard, SM. Park, Lean production, six sigma quality, TQM and company culture. The TQM magazine 18 (2006): 263-281.
[7] M. T. Chao, D. K. J. Lin, "Another look at the process capability index," Quality and Realiability Engineering 22 (2006) : 153-163.
[8] D. C. Montgomery, Introduction to Statistical Quality Control, Fourth edition, (2003), New York: John Wiley.
[9] J. M. Juran, "Strategies for world class quality", Quality progress 24, 2, (1991), P81-85.
[10] "Process Capability and Product Design" http://www.npd-solutions.com/proccap.html, accessed on May 6th , 2018.