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Quality control of palm kernel oil using Individual Moving Range (I-MR) chart
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Faculty of Engineering Universitas Malikussaleh, 24351 Aceh Indonesia Abstract: Quality
is one of the issues that requires special attention in the operation of a company since it
can affect the relationship between producers and consumers as well as reduce the
company's losses. PT.

Z is a company that mainly produces Crude Palm Oil (CPO) and Palm Kernel Oil (PKO).
The problem that often occurs in this factory is that the quality of processed palm kernel
is under the set standard of the company, especially palm kernel products, resulting in a
loss for the company indirectly. To minimize the losses, the quality control must be
conducted.

The purpose of this research is to control the quality of palm kernel by using individual
moving range (I-MR) chart. From the research result, it is found that the level of
impurities in the palm kernel products still require control because the value was above
the company's provision which is = while the research result was > 6.

1 Introduction Quality is one of the most important issues in a company because the
quality can change the relationship between producers and consumers and also can
also reduce the company's losses. PT. Z is a company whose main products are Crude
Palm Oil (CPO) and palm kernel. This research focused on Palm Kernel in one palm oil
processing industry, because palm kernel will produce KPO as a widely used raw
material in the food industry.

In palm kernel processing, the quality of processed products is determined by some

factors such as the nature of the parent tree s, post-harvest handling, transport and errors during processing. The quality of palm kernel products is measured from several parameters such as dirt content, moisture content and free fatty acid content.

The problem that often occurs in the palm oil factory is the palm kernel processing is still below the company standard, resulting in losses for the company indirectly. This standard includes definition, terms, classification, quality requirements, sampling methods, test, marking conditions, and packaging method[1][2]. According to SNI, the palm kernel is part of the fruit of *Elaeis guineensis* Jacq plant which has been separated from the flesh and shell and then dried [3].

Definition * Corresponding author: fatimahjtind@gmail.com MATEC Web of Conferences 204, 01006 (2018) <https://doi.org/10.1051/mateconf/201820401006> IMIEC 2018 of quality can be interpreted from two perspectives, namely from the consumer and the producer side. Good quality according to the producer is if the product produced by the company has been in accordance with the specifications that have been set by the company, while for consumers, good quality is when the products are in accordance with what they expect, have benefits that match their needs and equivalent with the amount of money they have spent for the products.

However, basically, the concept of quality is often regarded as conformity, the overall characteristics of a product expected by consumer. According to American Society For Quality (2010), "Quality is the totality of features and characteristics of a product or service that bears on its ability to satisfy stated or implied need. Edwards Deming (1982) states that quality is in conformity with market needs [4].

Suyadi Prawirosentono states that quality of a product is "the physical state, function, and nature of a product that can meet the taste and the needs of the consumers satisfactorily according to the amount of money that has been spent [5]. 1.1. Quality Control Quality control is the operational techniques and activities used to fulfill requirements for quality. Quality control must be done continuously.

One way to do the quality control is by applying PDCA (Plan - Do - Check - Action) introduced by W. Edwards Deming, a famous American quality expert, so then this cycle is called Deming Cycle / Deming Wheel. The PDCA cycle is generally used to test and implement changes to improve the performance of future products, processes or systems[6]. 1.2.

Statistical Quality Control Statistical Quality Control (SQC) is a system developed to maintain uniform standards of production quality, at minimum cost levels and

implement assistance to achieve efficiency [7]. Richard B (1997) suggests that Statistical Quality Control is a number of different techniques designed to evaluate quality of a conformance view.

"Meaning : Statistical quality control is a different technique designed to evaluate quality in terms of conformance with specifications [8][9]. 1.3. Control Map for Individual Unit Control Chart theory bases itself on the central limit theorem in statistics. This statement shows that when a subgroup or sample is taken from a series of processes and then the mean calculation of subgroup data is performed, then the mean will form a normal distribution. (although sometimes there is the possibility for abnormal distribution).

Therefore the area under the curve within the 3 standard deviation limit on the two sides is 99.73% of the total area under the normal curve. One commonly used description is the $\bar{X} \pm 3\sigma$ where \bar{X} is the symbol for standard deviation - a measure of deviation. This means that if there is mean of subgroup beyond the control limit, it has a probability of $1 - 99.73\%$, or 0.27% which is 2 MATEC Web of Conferences 204, 01006 (2018) <https://doi.org/10.1051/matecconf/201820401006> IMIEC 2018 addressed to the probability of a random error.

However, the 99.73% confidence level is due to deliberate control of the process intentionally or non-randomly. Hence the subgroup mean beyond the control limit should be further investigated. 1.4. Individual Control Chart of \bar{X} and MR This chart is used for process control whose sample size is only one ($n = 1$).

This often happens when the inspection is done automatically and at a very slow production level, making it difficult to take a sample size larger than one ($n > 1$). This case is common in the chemical industry. Control chart of \bar{X} dan MR (moving range) is set on the process which produces relatively homogenous products (for example chemical liquid), mineral content from water or food, cases where 100% inspection is used. The control procedure uses two consecutive sequences of moving range to estimate process variability.

Moving range calculation can be done with equation 1 [10]. $MR = \max(x_i) - \min(x_i)$ (1) Where : x_i : Product quality parameter on sub-group to i Furthermore, moving range control is performed using: $MR_{CL} = \frac{MR}{d_2}$ (5) d_2 is a constant value for n minimal ($n = 2$) 3 MATEC Web of Conferences 204, 01006 (2018) <https://doi.org/10.1051/matecconf/201820401006> IMIEC 2018 1.5.

Process Capability Analysis Determination of process capability is done after the process

is within the control limit. A process is said to be within the limit of control when variations that occur in the system are caused by variations of common causes. The process capability analysis is so important because it allows how well a process can make the product acceptable.

? 6 LSL-USL on Distributi Process ion Width Specificat Cp = = pouct,whers tsdddn f poss.Tgrterthe b it is. The criteria used for process capability index (Cp) are: - CP > 1.33; very good capability process - 1.33; capacity process is good, however, the tight control is needed when Cp has achieved 1,00. - Cp < 1.00; low process capability so that performance needs to be improved through process improvement.

After calculating the Cp, then the Cpk index value is calculated, ie: Cpk = Minimum {CPU, CPL} Dimana: ? 3 X -U S L CPU = ? 3 L S LX CPL - = 2. Research method The research method used was descriptive which is the study to make improvements to a previous situation. In addition, field observation and interviews were conducted with various parties including employees, head of department, and assistants directly related to the production process.

Data was processed by using statistical quality control method, with the following stages; calculated the value of MR (moving range), calculated the mean of X value, calculated the central line (X and MR) of the mean, calculate the X and MR map control limits for each data characteristic, described the control charts for each characteristic, made revisions when the re is data outside the control limit and lastly calculated the process capability index. 3.

Results and Discussion The measurement data was conducted based on observations made in the laboratory for the dirt content(%), water content (%) and the ALB content (%) of palm kernel oil for 30 days. Data processing was done for each quality requirement of observed palm kernel. Then the determination of upper and lower limit for MR and Xbar and their capabilities was conducted.

Using equations 2, 3 and 4, the following values were obtained: 4 MATEC Web of Conferences 204, 01006 (2018) <https://doi.org/10.1051/matecconf/201820401006> IMIEC 2018 3.1. MR and Individual Control Chart of dirt content data 16,0 MR CLMR == 53, 0) 16,0)(267,3(MR DU C L 4 MR = == 0) 16,0)(0(MR DL C L 3 MR = == The MRi data plot was conducted on the control chart and observation was done to know whether or not the level of dirt content is in control, as shown in Figure 1. Fig. 1.

Moving range control chart of dirt content. Figure 1 shows that there was out-of-control data. Therefore it is necessary to revise, that is by taking out the out-of-control data.

After being revised for two times, the data was in all control. The calculation is as follows
 $0,13 \text{ MR CL MR} = = = = = = \text{ Fig.2. Moving range control chart of dirt content as the result of second revision.}$

Based on the control limit as shown in Figure 2, it appears that there is no more out-of-control data. Now the remaining data is only 28 data after 2 revisions. This data was examined to see its variability by using x-chart. Using the equation 5, 6, 7, values for the X-bar diagram of the dirt content were obtained as follows: $\text{CLx} = 32,6 \text{ X} = = = + = + 5$
 MATEC Web of Conferences 204, 01006 (2018)
<https://doi.org/10.1051/mateconf/201820401006> IMIEC 2018 $\text{LCLx} = 97,5 \text{ UCLx} = 32,6 \text{ MR} = 3,2 = \text{ Fig. 3.}$

Individual control chart of dirt content. It can be seen in the picture that the data is in control. This shows that the data did not experience assignable variability. To prove it, the calculation of the ratio of process capability was conducted. The calculation of the process capability ratio (Cp) as follows: $1,128,13,0697,566,66 \text{ LCL-UCL Cp} = ? ? ? ? ? ? - = ? = ? ? ? ? ? ? - = - = ? = ? ? ? ? ? ? - = - = ? () ? ? () ? ? = = ? ? ? ? ? ? - = = ? 3.2.$

MR and Individual Chart of moisture data $21,0 \text{ MR CL MR} = = 68,0) 21,0) (267,3 (\text{ MR DU C L 4 MR} = = = 0) 21,0) (0(\text{ MR DL C L 3 MR} = = = \text{ The MRi data plot was conducted on the control chart and observation was done to know whether or not the data of moisture is in control, as shown in Figure 4. 6 MATEC Web of Conferences 204, 01006 (2018) } <https://doi.org/10.1051/mateconf/201820401006> IMIEC 2018 Fig. 4. Moving range control chart of moisture.$

It can be seen in Figure 4 that there is out-of-control data. Therefore revision is necessary by eliminating the out-of-control data. After revision for one time, the data was in control. Here is the calculation. $16,0 \text{ MR CL MR} = = 51,0) 16,0) (267,3(\text{ MR DU C L 4 MR} = = = 0) 16,0) (0(\text{ MR DL C L 3 MR} = = = \text{ Moving range Control chart of moisture content can be seen in Figure 5. Fig.5. Moving range control chart of moisture content as the result of revision I.}$

Based on the control limits as shown in Figure 5 it is seen that there is no more out-of-control data. Now the remaining data was only 28 data after 1 revision. The variability of this data then observed by using x-chart. Using the above equation, the value for the X-bar diagram of moisture data is as follows: $\text{CLx} = 38,6 \text{ X} = = + = + = + = - - - - - 7$ MATEC Web of Conferences 204, 01006 (2018)
<https://doi.org/10.1051/mateconf/201820401006> IMIEC 2018 Fig.6 .Individual control chart of moisture Content.

Figure 6 shows that there was data which is still in out-of-control condition. This indicates that the data experienced assignable variability. The calculation of the ratio of process capability was done to prove it: $1.128, 1.16, 0.697, 0.580, 0.66$ LCL-UCL Cp = ???
 ??? - = = ? = ??? ? ? ? ? - - = ? = ? ? ? ? ? ? - - = ? () ? ? () ? ? = ? ? ? ? ? ? - = = ?
 3.3 .

MR and Individual Chart of ALB Content data 01,0 MR CL MR == 0.45, 0.01, 0.01 (2.67, 3 (MR DU C L 4 MR = == 0) 01,0)(0(MR DL C L 3 MR = == The plot of the MRi data was performed on the control chart followed by observing whether the ALB data is in control or not, as shown in Figure 7. 8 MATEC Web of Conferences 204, 01006 (2018) <https://doi.org/10.1051/mateconf/201820401006> IMIEC 2018 Fig.7. Moving range control chart of ALB content.

From Figure 7 it can be seen that there was no out-of-control data. Therefore no revision is necessary. Based on the control limits as shown in Figure 8, it appears that there was no more out-of-control data. Now the remaining data was 30 and they were observed for their variability by using x-chart.

Using the above equation, the value received for X-bar chart from the data of ALB content as follows: $CLx = 76, 0X = = + = + = + = -$ Fig.8. Individual control chart of ALB Content. The picture shows that the data was in control condition. This means that the data did not experience assignable variability. To prove it, the calculation of the ratio of process capability was performed.

$1.128, 1.01, 0.673, 0.80, 0.6$ LCL-UCL Cp = ? ? ? ? ? ? - = = ? 9 MATEC Web of Conferences 204, 01006 (2018) <https://doi.org/10.1051/mateconf/201820401006> IMIEC 2018 $1.128, 1.01, 0.373, 0.76, 0.3$ L C LX Cpl = ? ? ? ? ? ? - - = ? $1.128, 1.01, 0.376, 0.80, 0.3$ XU C L Cpu = ? ? ? ? ? ? - - = ? () ? ? () ? ? 1.04 .0 04 .0

$1.128, 1.01, 0.3$ L C LX or X - U C L m i n 3 Cpl or C p u m i n Cpk == ? ? ? ? ? ? - = = ? Based on the size of the work index, it can be seen that Cp = 1.00 suggesting that the process capability is good, but it needs strict control and can still be improved again the quality and performance through improvement process where the specifications were out of limits. While Cpk = 1.00, so the process of producing products were in accordance with the specifications.

Cpk = Cp then process was centered Æ ideal. 4. Conclusion Based on the the results of the discussion, it is found out that the value of dirt content was above the upper control limit (UCL)so it must be revised twice by eliminating the data causing the out-of-control

condition so that the remaining data in the test of quality variability condition is 28 data with the result of $UCL = 6.66$, $CL = 6.39$ and $LCL = 5.97$. This condition is called assignable variation and therefore the source of the problem must be traced. The result of process capability ratio also shows that the process capability can be said good because $C_p = 1$, but strict control is needed on production process.

Therefore, this condition should not be allowed and must be resolved immediately. In MR -Chart of moisture content, its value was above the upper control limit (UCL) so it must be revised once by eliminating the data that causes the condition out of control, and the remaining data in the test of quality variability condition is 28 data. With individual chart, there were 5 out of control data (1,2,3,4 and 13) with result of $UCL = 6.80$, $CL = 6.38$ and $LCL = 5.97$.

This condition is called assignable variation and the cause of the problem must be investigated. The result of process capability ratio also shows that the process capability can be said good because $C_p = 1$, but need strict control on production process. Therefore, this condition should not be allowed and must be addressed.

At MR -Chart, the level of ALAL B did not show that ALB content is above the upper control limit (UCL), so there was no revision of data. Next, on individual chart there was no out of control data with the result of $UCL = 0.80$, $CL = 0.76$ and $LCL = 0.73$. The result of process capability ratio shows that the process capability can be categorized as good because $C_p = 1$, it shows the product quality can be improved even better by controlling the production process strictly. The cause of quality improvement problems must be explored.

Overall, based on the value of the three quality requirements that were analyzed when compared with the company's quality standards, it was only kernel palm moisture content that needs tight control. References 1. M. H. Noviar, Sukardi, and A. Rifin, 6 (2016) 10 MATEC Web of Conferences 204, 01006 (2018) <https://doi.org/10.1051/mateconf/201820401006> IMIEC 2018 2. M. Hudori, (2015) 3. Badan Standarisasi Nasional; SNI Crude Palm Oil . Jakarta, (2006) 4. Deming W.

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