Ability analysis of ink production process offset in XYZ company

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Abstract. XYZ Company a company that produces Security Printing. Security printing of a quality security document and high security value. To that end, then the company must create a security document with high technology and good handling so that quality is maintained. The main raw material for printing security documents is ink, in which the ink is produced by the ink-making section. In the process of testing the ink quality (especially offset ink) it is found that the high ink product is not suitable (defect) as the ink color does not match the standard. Thus, the researcher aims to find out the index ability of ink production process offset at the company. The research methods collect and process data such as data normality test, control chart creation, process capability analysis, and determine the proposed improvement using Plan Do Check Action (PDCA) cycle and brainstorming, cause and effect diagram, and Failure Mode Effect Analysis (FMEA). The result of research that the ink production process capability of offset color parameter has not fulfilled the quality according to the specification, because the value of process capability index (Cpk) <1 is 0.91. Thus, the undocumented standard of ink-making formulas is not documented, so the RPN value is high so it needs to be improved by "creating a standard document of a validated and controlled ink formulation formula".

Keywords: Ink offset, process capability, PDCA, FMEA

1. Introduction
XYZ Company is a printing company that produces Security Printing. The production of security printing must be able to maintain the quality and continuously improve the quality of its products by continuously performing quality control in each production process so that the products are in accordance with the quality that consumers want in accordance with work instructions [1]. The main raw material of security document printing (security printing) was ink form. Supply of raw materials (offset ink) from an independent Inkjet-Making Unit (Batanta) in the manufacture of ink for the security document. Offset ink produced by Batanta Unit one of them is pigment based ink. Ink quality offset testing by the Rescue Analytical Unit (Quality Control Department) is often found to be an inconsistency between the quality characteristics of the offset ink with the specifications. Thus, the current offset ink still has the potential to cause defects in security printing products such as bald, ink stain, dry slow ink and over density. Recapitulation of offset ink production data rejected during 2015 from total production of 169 batches see Table 1 below.
Table 1. Offset ink production data rejected during Year 2015

<table>
<thead>
<tr>
<th>Period</th>
<th>Color no match</th>
<th>Slow dry</th>
<th>Too rugh</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Reject %</td>
<td>Reject %</td>
<td>Reject %</td>
</tr>
<tr>
<td>Quarter 1</td>
<td>8</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Quarter 2</td>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Quarter 3</td>
<td>5</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Quarter 4</td>
<td>6</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>21</td>
<td>9</td>
<td>4</td>
</tr>
</tbody>
</table>

Source: Data defects are processed XYZ Company 2015

The high offset ink product defects due to inappropriate color or deviation from the standard can cause losses, such as: increased time to redecorate the resulting ink, thereby reducing the cost of repair and the waiting time on the offset printing process. To improve the quality of the Batanta Unit offset production ink it is necessary to know how much the ability of the production process to meet the specified specifications.

2. Research Methodology

Research methodology undertaken made initial observations on security printing production process. Then take the defect data of production as follows:

a. Statistics Description, is a method associated with the collection of research data and measurement of statistical values (mean, standard deviation, etc.), so it can be used to obtain the desired information.

b. Normal Distribution, good data and feasible to be used in research is data which have normal distribution, meaning that data have spread evenly so that really represent population. Therefore, the data normality test is performed before the data is processed to determine whether the data in the variable to be analyzed is normally distributed.

c. Chart Control, Calculation and manufacture of control limits and criteria according to product specifications such as UCL, CL and LCL.

d. Process Capability Analysis

Furthermore, calculate the process capability to meet the expected criteria and specifications.

2.1. Process Capability Rate (Cp)

\[
\begin{align*}
Cp &= \frac{USL - LSL}{6\sigma} \\
\sigma &= \frac{R_\text{max} - R_\text{min}}{D_2}
\end{align*}
\]

(1)

(2)

Where:

- USL = The largest value measurement result
- LSL = Smallest value measurement result
- \( \Sigma \) = Sigma
- \( R = X_{\text{max}} - X_{\text{min}} \) Average
- \( D_2 \) = coefficient value (table coefficient)

Information:

- \( Cp > 1.33 \) = Then the process capability is very good
- \( 1.00 \leq Cp \leq 1.33 \) = Then good process capability, need strict control
- \( Cp < 1.00 \) = Then the process capability is low

2.2. Upper Process Capability Index (CPU) and Lower (CPL)

Process capability (Cp), Upper Process Capability (KPA) or lower processing capability (CDE) are used to evaluate specified limits of specifications. \( CPU = USL - \mu 3\sigma \) and \( CPL = \mu - \sigma 3\sigma \)

Where:
USL = upper specification limit  
LSL = lower specification limit  
\( \mu \) = average process  
\( \Sigma \) = deviation / standard deviation

2.3. Process Capability Index (Cpk)  
\( Cpk = \min \{ \frac{USL - \mu}{3\Sigma}, \frac{\mu - LSL}{3\Sigma} \} \). The assessment criteria used are as follows:  
- \( \mu \)The Cpk value represents the true capability of a process with a certain value parameter.  
- \( \mu \)Cpk < 1, then the process is considered not able to meet the existing specification limits.  
- \( \mu \)Cpk = 1, then the process is considered sufficient to meet the existing specification limits, but strict control is required.  
- \( \mu \)Cpk > 1, then the process is considered able to meet the existing specification limits.  

Continuous Quality Control Measures  
The process of quality control can be done one of them through the implementation of PDCA (Plan - Do - Check - Action) introduced by Dr. W. Edwards Deming. The PDCA cycle is commonly used to test and implement changes to improve the performance of future products, processes or systems

3. Result and Discussion  
After passing the normality test because the value of Sig Shapiro-Wilk method > 0.05 to the result of color data of offset ink has been distributed normally, it means that the data has evenly distributed so that really represent the population. Next make the control chart as follows:

![Figure 1. Control chart X](image)

The control chart above states that all samples are within the control or control limits.

![Figure 2. Control chart R](image)
The control chart R above also states that all samples are within the control or control limits.

3.1. Process Capability Analysis

3.1.1. Process Capability Rate (Cp) Analysis. Next to know the value of Cp, it must be known the value of R and the known ΔE specification is 1.50 ± 1.00. It is known that the value of R is 0.57. The upper specification limit (USL) is 2.50 and the lower specification limit (LSL) is 0.50. Then the process capability ratio (Cp) production of offset ink at XYZ Company can be calculated by

\[ \text{Cp} = \frac{\text{USL} - \text{LSL}}{6 \times \sigma} \]

\[ \sigma = \frac{\Sigma}{d_2} = \frac{0.571693}{0.57} = 0.34; \]

\[ \text{Cp} = \frac{2.50 - 0.50}{0.34} = 6.47. \]

The value of Cp <1, then means the process performance is not good or still low.

3.1.2. Process capability index (Cpk) Analysis. Having known the value of Cpu and Cpl, then made Cpk (Process Capability Index) which represents the true ability of a process with a certain parameter value. Here's the calculation:

\[ \text{Cpk} = \min \{ \text{Cpu}, \text{Cpl} \} \]

\[ \text{Cpk} = \min \{ 1.05, 0.91 \} = 0.91. \]

Because Cpk <1, then the process is considered not able to meet the existing specification limits. This indicates that the offset ink production process has not fully fulfilled the specified specification so that it must be repaired.

3.2. Analysis of data processing results

Brainstorming results are expressed in Cause Effects Diagram (Cause Effect Diagram) or often known as Fishbone Diagram. Using Failure Mode Effect Analysis (FMEA) tools, to check for potential product or process failures, to evaluate risk priorities, and to help determine appropriate actions to avoid identified problems. Risk Priority Number (RPN) causes the problem that has the highest value which then we can make as a priority improvement.

<table>
<thead>
<tr>
<th>Potential failure</th>
<th>Potential effect failure</th>
<th>Potential causes failure</th>
<th>SEV</th>
<th>OCC</th>
<th>DET</th>
<th>RPN</th>
<th>RANK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Offset ink color does not meet specifications</td>
<td>Increasing the time to rectify the resulting ink so that the waiting time of offset printing due to ink is not yet available. And the loss of repair cost and penalty of delivery to the consumer</td>
<td>Defferences in pigment characteristics, The greeting operator interpret the model/color the user wants, There is no documented standard ink making formula, Setting machine not in accordance with work instruction</td>
<td>7</td>
<td>6</td>
<td>3</td>
<td>126</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Defferences in pigment characteristics</td>
<td>7</td>
<td>6</td>
<td>2</td>
<td>84</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The greeting operator interpret the model/color the user wants</td>
<td>7</td>
<td>7</td>
<td>4</td>
<td>196</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>There is no documented standard ink making formula</td>
<td>6</td>
<td>4</td>
<td>2</td>
<td>48</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Setting machine not in accordance with work instruction</td>
<td>6</td>
<td>5</td>
<td>2</td>
<td>60</td>
<td>4</td>
</tr>
</tbody>
</table>

3.3. Proposed Improvement

From Table 3. The ranking of error method error (FMEA) Cause Ink Color is not suitable Specification as follows:
Table 3. Rank Potential causes

<table>
<thead>
<tr>
<th>No</th>
<th>Potential Causes</th>
<th>RPN</th>
<th>Proposed Improvement</th>
</tr>
</thead>
</table>
| 1  | There is no documented standard ink-making formula   | 196 | • Create a standard document of ink-making formula, in accordance with the historical record of ink-making.  
    |                                                       |     | • Validate the document, and archive the standard documents neatly                     |
| 2  | Differences in pigment characteristics                | 126 | • Look for pigments that share characteristics similar to those used previously.    
    |                                                       |     | • Test the characteristics of substitution pigments first, so that the characteristics used are appropriate.  
    |                                                       |     | • The test is done with color parameters, smoothness and endurance test, on chemical solvent, etc. |
| 3  | The greeting operator interprets the model / color the user wants | 84  | Sharing sharing and technical discussions between operators and unknown heads of units / sections on the interpretation of the model / color desired by the user (product design unit, proof unit, and print unit) |
| 4  | Setting machine not in accordance with Work instructions (IK) | 60  | • Setting the machine accordance IK  
    |                                                       |     | • Set the initial set up on the mixing machine or grinding machine.  
    |                                                       |     | • Paste the process on the machine                                                   |
| 5  | The equipment used is less clean                      | 48  | • Cleaning equipment and machines after use  
    |                                                       |     | • Check the equipment after use after cleaning                                       |

4. Conclusion

Conclusion of research result as follow:

1. The results of data processing obtained value of process capability index (Cpk) <1 is 0.91, this indicates that the ability of offset ink production process in terms of color parameters has not met the specification

2. Factors that cause the ink color is not in accordance with the standards, as follows:
   a. Material Factor, that is substitution of unstable pigment material because of difference of characteristic of pigment material used.
   b. Human factors, namely: the search for color ink (matching color) is not appropriate because of a mistake interpretation of the model / color desired user (order work unit); As well as the absence of historical document in ink formulas because the operator did not record the results of determining the new ink formula, which resulted in the undocumented standards of the ink-making formula.
   c. Machine Factor, ie: mixing result is not homogeneous because machine setting not according to work instruction; And the contamination of impurities caused by the equipment used is not / less clean.
   d. Factor Method, namely the document storage system formulation of ink formation is not neat that resulted in not documented standard ink-making formula
   e. The main factor causing the ink color is not standardized is "not documented standard ink-making formula" because it has the highest RPN value.

3. Proposed improvements to reduce the main cause factors, as follows:
   a. Create a standard document of ink-making formula, in accordance with the historical record of ink-making.
   b. Validate the document, and archive the standard documents neatly.
5. References