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Application of Quality Control and Risk Management in Maintaining Product Quality with A Risk Breakdown Structure Approach

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ABSTRACT

This research was conducted in a company that operates in the printing or graphics sector. The concept of quality control is the most critical part because newspapers or printed media are products with the fastest production process. PT carries out the quality control process. PT XYZ to lower the failed results on the paper. Quality control measurements use the P chart method—results of quality control measurements at PT. XYZ is outside the control limits, which is not normal, so corrective action is needed, especially the number of failed newspapers. On average, newspapers fell from January to May, reaching 8.24% of the total newspapers produced. Events that cause failure in newspapers are analyzed through risk management. Risk management measurements use the Risk Breakdown Structure (RBS) and Fault Tree Analysis (FTA) methods. Risk management results show that five risks cause newspaper failure: scattered ink, slanted fonts, blurred images, dirty images, and thick fonts.

Keywords: Newspaper, Quality Control, Risk Management, Risk Breakdown Structure, Fault Tree Analysis

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INTRODUCTION

Quality control is a set of actions in a production or service process to ensure that the product or service produced conforms to established quality standards. Quality control aims to identify, prevent, or mitigate errors or failures that may occur during the production or service process [1].

PT. XYZ uses technology that is simpler than competitors in its industry. Delays in distributing newspapers still occur because the machine used is the existing Goos Community machine from the company that opened in 2005. This proves that technology alone does not guarantee a smooth production process. Optimal production is not only timely production but also production that can

minimize the amount of raw material waste or, in other words, must be able to use natural materials optimally. The destruction of Newspaper raw materials such as paper and ink must be considered by companies so that production costs and the number of failed products can be reduced as low as possible. The cause of the product failure is also due to a lack of maintenance on the machine. Production activities become more effective and efficient by reducing the amount of waste.

Based on the survey results at PT. XYZ has problems that companies often experience. PT. XYZ has several processes for producing newspaper products. In the printing process, ink blur occurs, so the print results are not optimal. This problem interferes with the following method. Without improvement, the company will experience losses because the paper will be unused and thrown away. Then, the color is destroyed during printing, and the color is destroyed, which is caused by a lack of maintenance and repair of the machine. This can cause many products to fail miserably. The next problem is the Italic Font caused by the tilted printing plate. The issue of forgetting the product always exists whenever the company produces newspapers. This makes newspaper production not optimal because materials are ineffective, producing many failed products.

Referring to Problems at PT. XYZ can then be seen in Figure 1, showing the number of failed products that often occur from January to May 2022. It can be known that the problem of quality control is the quality of PT products. XYZ needs a more in-depth study to control quality. Conducting research on Production Process Control Analysis, with the problem that the amount of production carried out by the company each month is not the same. This is because determining the number of products is based on the number of orders the company receives. The total production from January to May 2022, with a total of 152 days, amounted to 365,369 copies, with an unlimited number of newspapers that failed output of 44,299 copies or with a percentage of damage in January to May 2022 of 8.24%.

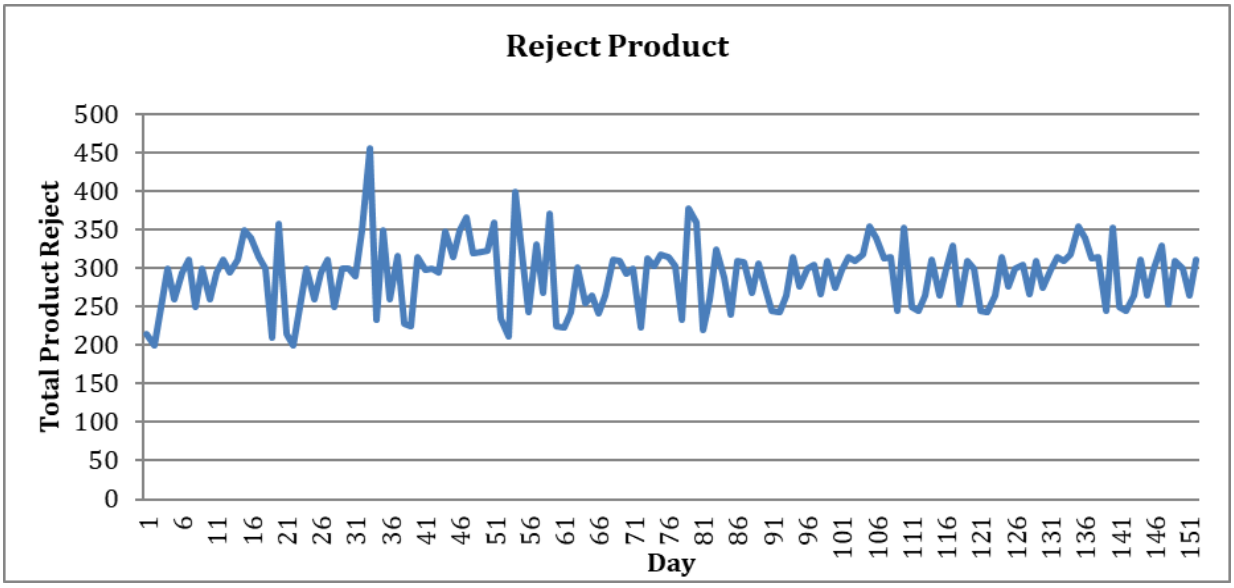

Figure 1. Total Reject Products Graph

With problems in the production process, Quality Control is needed. Quality Control is a technique and activities or planned actions used in quality control that are useful for achieving, maintaining, and improving the quality of a product to meet predetermined quality standards and satisfy customers [2]. Quality Control aims to retain and sustain predetermined rate. The existence of a Control Chart using the P-Chart method is used in the control map to calculate products that experience a failed production process because, for companies, a failed product is the same as a failed product that

cannot be reused. P-chart aims to control the proportion of failed products produced in a production process, while the U-chart seeks to monitor the number of failed products in fixed-sized samples [3][4].

There are risks as a result of various problems in the production process. Uncertainties that are impossible to foresee mean that risks will always be present. This risk can result in losses that must be borne by the company [5][6]. Output risk is an uncertainty that directly impacts a firm's output in terms of quantity and quality or results in changes in planned production output. There are three different categories of sources of risk: physical, social, and economic. Biological risk sources include natural disasters and human error [7]. Sources of social risk include societal or individual actions that lead to deviations that result in harm and go against expectations [8][9].

Failed products become a source of risk to quality caused by poorly trained workers with a lack of skills, unsuitable raw materials from distributors, and a lack of risk-based assessment [10]. Risk is related to the possibility of losses with adverse consequences and unexpected presence, so risk management needs to be done [11]. Risk management is a way to deal with various problems arising from risk [12][13]. The need for Risk Management is carried out using the Risk breakdown structure method and Fault tree analysis. Risk breakdown structure is the grouping of risk in a composition that is logical, systematic, and structured naturally according to the organizational structure or project [14]. Fault tree analysis identifies risk occurrence by describing alternative events in a structured block diagram [15].

When managing production risks due to employee factors, employees are encouraged to follow established SOPs and be careful in all tasks [16]. In terms of material, the steps taken by employees of PT. XYZ, among others, double-checks the raw materials received before use to see whether the raw materials are needed or not and ensures that the dishes provided are clean and packaged correctly [17]. From the engine side, monitor the readiness of the machine to be used and carry out routine machine maintenance, not only when the device is damaged but also in efforts to prevent unwanted things such as more severe engine damage [18].

Some studies on Quality control include [19] the Application of Quality Control and Risk Management in Maintaining Product Quality using Control Charts with P-Chart and C-Chart methods. Risk Management uses Risk breakdown structure and Fault tree analysis methods. Daniel [20] did almost the same research, namely the Evaluation of Production Results with C-Chart and U-Chart Quality Control Methods at the Generator Sets Factory. These two studies used the same method, namely the Control Chart. The difference is that this research was conducted in a bread factory and a Generator Sets Factory, where the difference was carried out by printing daily newspapers. In this study, researchers used data on the number of failed products. Because newspaper production only provides data on the number of failed products. This research uses Quality Control with P-Chart and U-Chart methods. Risk Management uses the Risk breakdown structure method and Fault tree analysis [20][21].

Based on the problems at PT. XYZ, the application of Quality Control and Risk Management is expected to contribute to quality improvement through reducing product failures during the production process. Reduction of failed products can be anticipated through Quality Control and Risk Management—a massive increase in PT production results and profit levels. XYZ is the expected response.

METHOD

Data Collection

Data Collection Methods The methods carried out in data collection are [22]:

1. Observation

An observational approach uses observations to collect data—live monitoring of PT. XYZ is finished at this time [23].

2. Interview

Employee Interview PT. XYZ printing newspapers is a method of data collection. PT. Printing process of PT. XYZ experienced a product failure. Therefore, risk management and quality control specialists conducted a question-and-answer session utilizing the business profile [24][25].

Data Processing

Data processing is carried out in two stages. The first stage of data processing measures Quality Control, and the second stage is Risk Management [26].

1. Quality Control

Quality Control process using Control Chart with P-Chart and U-Chart methods [27].

2. Risk Management

Risk Management analyses what risks might cause printed newspapers to become failed products. The Risk Management process is carried out through 3 stages: risk identification, risk assessment, and handling. The identification process is carried out to determine the cause of the risk. With Risk breakdown structure method and Fault tree analysis [28][29].

RESULTS

This study used primary data such as observations, interviews, newspaper productions, and failed products from January to May 2022. Data processing begins with measurements of Quality Control. Activities quality control to improve the quality of newspapers that have been rejected. Table 1. Shows leave newspaper data for five months of observation.

Table 1. Reject Newspaper for five months

Day To	Number of Rejects	Number of Products	Day To	Number of Rejects	Number of Products
1	214	2100	148	214	2100
2	200	2015	149	200	2015
3	250	2300	150	250	2300
4	300	2500	151	300	2500
5	260	2200	152	260	2200

Data processing begins with measurements of Quality Control. Quality Control activities on quality improvements in products that have failed production. Measurement of newspaper results that failed to be carried out for five months. From January 2022 to May 2022. Quality Control measurement begins using a control map. The control maps used are P-Chart. P-Chart was chosen because of the varying observation size. Here are the P-Chart calculation steps:

1. Calculating Proportions

$$P = \frac{np}{n} = \frac{214}{2100} = 0.102$$

2. Calculating the Center Line

$$CL = \overline{P} = \frac{\sum np}{\sum n} = \frac{43723}{360715} = 0.121$$

3. Calculating the Upper Control Limit (UCL)

$$UCL = \overline{P} + 3\frac{\sqrt{\overline{P}(1-\overline{P})}}{n} = 0.121 + 3\frac{\sqrt{0.121(1-0{,}121)}}{2100} = 0.143$$

4. Calculating the Lower Control Limit (LCL)

$$LCL = \overline{P} - 3\frac{\sqrt{\overline{P}(1-\overline{P})}}{n} = 0.121 - 3\frac{\sqrt{0.121(1-0{,}121)}}{2100} = 0.100$$

5. Create a P-Chart

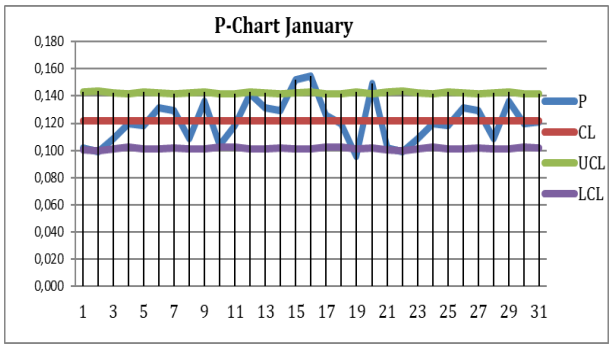

Figure 2. P-Chart January

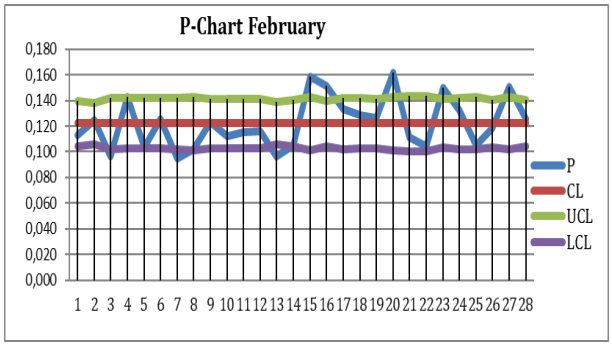

Figure 3. P-Chart February

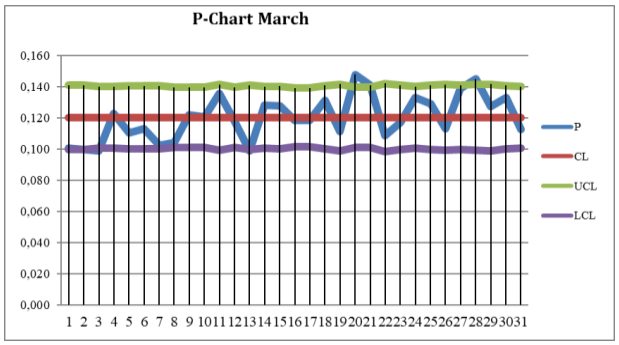

Figure 4. March P-Chart

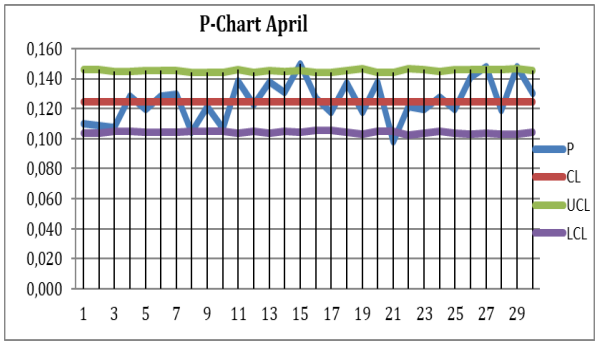

Figure 5. P-Chart April

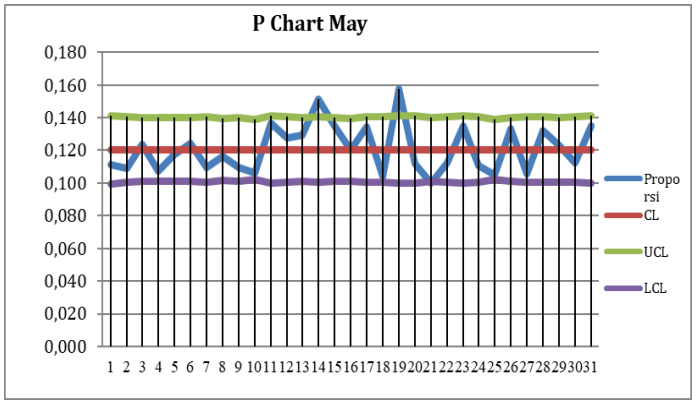

Figure 6. May P-Chart

Figure 2 shows the failures outside the UCL line on the p-chart control map, namely in January on days 12, 15, 16, and 20 of 0.143, 0.142, 0.142, and 0.142. There is a proportion of failures outside the LCL line on day 19 of 0.101, so it can be said that the process is still not under control. Figure 3 shows the losses outside the UCL line on the control map p in February on days 4, 15, 16, 23, and 27 of 0.142, 0.143, 0.140, 0.141, and 0.143. there is a proportion of failures outside the LCL line on days 3, 7, and 13 of 0.102, 0.102, and 0.106, so it can be said that the process is still not under control. Figure 4 shows the proportions of failures outside the UCL line on the P-Chart control map, namely in March on days 20, 21, and 28 of 0.140, 0.140, and 0.141. there were proportions of failures outside the LCL line on days 3 and 13 of 0.101 and 0.100. Figure 5 shows the failures outside the UCL line on

the control map p in April on days 15 and 27 of 0.105 and 0.105. there were proportions of losses outside the LCL line on days 8 and 21 of 0.105 and 0.105. Figure 6 shows the proportions of failures outside the UCL line on the p-control map, namely in May on days 14 and 19 of 0.141 and 0.141. there is a proportion of losses outside the LCL line on day 21 of 0.101, so it can be said that the process is still not under control.

Risk Breakdown Structure

Table 2 aims to determine which risks must be addressed first—risk identification method using Risk Breakdown Structure. The Risk Breakdown Structure provides a hierarchically identified picture of risks arranged by risk categories and subcategories of potential risks. Leveling risk categories based on levels start from stage zero as a risky program and are then further divided into specific sub-risks.

Table 2. Risk Breakdown Structure

Level 0	Level 1	Level 2	Level 3
0	1. Engine	1. A. Dirty engine	1.A.1 Untidy image
			1.A.2 Dirty writing results
			1.A.3 Scatter Ink
		1.B. Inconsistent engine regulations	1.B.1 Fon*t* thickness
			1.B.2 Image blur
		1. C. Poor engine maintenance	1.C.1 Engine off
			1.C.2 Unsatisfactory print results
	2. Labor	2. A. Setting errors	2.A.1 Paper size does not fit
			2.A.2 Paper thickness
			2.A.3 Italic font
	3. Environment	3. A. Small Room	3.A.1 Stacking
			3.A.2 Damp newspapers
		3.B. Bad Artistry	3.B.1 Accumulated garbage
			3.B.2 Dirty

Table 2 shows the Risk Breakdown Structure of the risk causes of a failed newspaper. Risks are grouped according to levels 0 as a risky program and 1, which means identifying risk categories in PT. XYZ is machinery, labor, and environment. Level 2 is called the Subcategory for risks identified at PT. XYZ has a dirty engine with inconsistent engine rules, poor engine maintenance, setting errors, small rooms, and poor art at level 3, identifying the specific risks of each Subcategory in PT. XYZ is untidy images, dirty writing, scattered ink, font thickness, blurry photos, machine off, improper paper size, paper thickness, italic fonts, stacking, damp newspapers, Garbage piled up, and dirty and unsatisfactory print results.

Fault Tree Analysis (FTA)

Making error salts aims to provide an overview of the risk list based on the structure with gate, event, and transfer relationships. Making fault diagrams is the initial stage of Fault Tree Analysis. Figure 7 is the problem of the Risk Breakdown Structure.

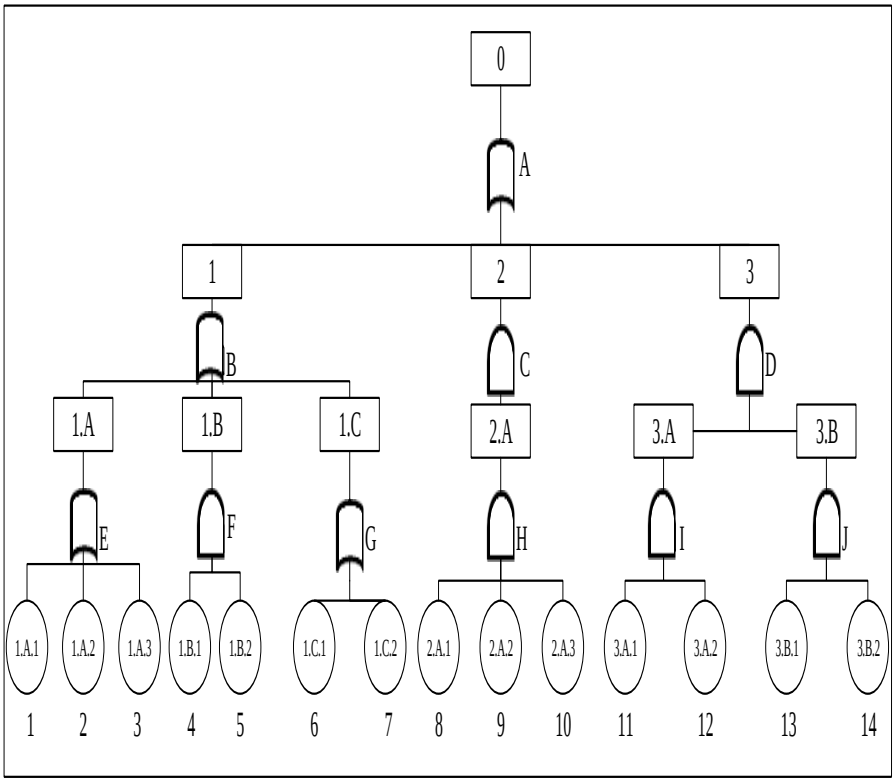

Figure 7. Fault Tree Analysis

The calculation of Basic Events is based on observations with a formula comparing the average number of failed newspapers due to certain risks to the average number of newspapers per day—known data on the calculation of risk events.

$$P_n = \frac{\bar{x}\text{Risk events}}{\bar{x}\text{Newspaper results}}$$

Information:

Pn = Probability result

x̄ Risk events = Average risk events per day for one month in the observation period of 5 months

x̄ Newspaper Results = Average number of newspapers per day for one month in a 5-month observation period

Table 3. Primary Even Probability Calculation Results

Probability to	Calculation Results	Probability to	Calculation Results	Probability to	Calculation Results
P1	$=\frac{608}{4229}=0.4137$	**P6**	$=\frac{10}{4229}=0.0023$	**P11**	$=\frac{100}{4229}=0.0236$
P2	$=\frac{300}{4229}=0.0709$	**P7**	$=\frac{160}{4229}=0.0378$	**P12**	$=\frac{12}{4229}=0.0028$
P3	$=\frac{912}{4229}=0.2156$	**P8**	$=\frac{5}{4229}=0.0011$	**P13**	$=\frac{168}{4229}=0.0397$
P4	$=\frac{308}{4229}=0.0728$	**P9**	$=\frac{142}{4229}=0.0335$	**P14**	$=\frac{390}{4229}=0.0927$

P5	$= \frac{558}{4229}$=0.1319	**P10**	$= \frac{760}{4229}$=0.1797

Logic Expression Calculation

Logic Expression calculations are used to calculate the relationship of the Basic Event. The connection from the Basic Event enters the gate group from the symbols in the Fault Tree Analysis.

Table 4 Logic Expression

Gate	Calculation Results
A	Gate B ∪ Gate C ∪ Gate D = 1.0858 + 0.1797 + 0.00000015 = 1.26550015
B	Gate E ∪ Gate f ∪ Gate G = 0.7011 + 0.0077 + 0.377 = 1.0858
C	Gate H = 0.1797
D	Gate I ∩ Gate J = 0.00006 x 0.0025 = 0.00000015
E	1 ∪ 2 ∪ 3 = 0.4137 + 0.0709 + 0.2156 = 0.7002
F	4 ∩ 5 = 0.0728 x 0.1319 = 0.009602
G	6 ∪ 7 = 0.0023 + 0.0378 = 0.0401
H	8 ∩ 9 ∩ 10 = 0.0011 x 0.0335 x 0.1797 = 0.000006621
I	11 ∩ 12 = 0.0236 x 0.0028 = 0.000066
J	13 ∩ 14 = 0.0397 x 0.0927 = 0.00366034

Method of Cut Set (MCS) Calculation

Method of Cut Set calculation based on the most minor combination of primary events. The selection of varieties adjusts to the most minor gate result of the sub-risk. The most negligible gate result is found at gate H of 0.000006621. The information from gate H is used as a Method of Cut Set calculation. The calculation results of the Method of Cut Set are as follows:

Gate H = Cut Satay 8+9+10
= (0.0011 + 0.0335 + 0.1797)
=0.2143

Risk Reduction Worth (RTW) Calculation

Risk Reduction Worth calculation determines which sub-risks affect newspaper failure's cause—risk Reduction Worth Calculation in Table 5.

Table 5 Minimal Cut Set of Risk Indicators for the Causes of Reject

Cut Set	Probability	Cut Set	Probability
1	0.4137	8	0.0011
2	0.0709	9	0.0335
3	0.2156	10	0.1797
4	0.0728	11	0.0236
5	0.1078	12	0.0028
6	0.0023	13	0.0397
7	0.0378	14	0.0927

$$RRWn = \frac{MCS}{MCS\text{-}Pn}$$

Description:

RRWn =Risk Reduction Worth
Pn =Probability result
MCS =Method of Cut Set

Table 6. RRW Value Calculation for Each Basic Event Risk of Causing Newspaper Reject

Basic Set and RRW To-	Basic Set and RRW To-
$RRW_1 = \frac{0.2143}{0.2143\text{-}0.4137} = \frac{0,2143}{0,1994} = 1.0747$	$RRW_8 = \frac{0.2143}{0.2143\text{-}0.0011} = \frac{0.2143}{0.2132} = 1.0051$
$RRW_2 = \frac{0.2143}{0.2143\text{-}0.0709} = \frac{0,2143}{0,1434} = 1.4944$	$RRW_9 = \frac{0,2143}{0,2143\text{-}0,0335} = \frac{0.2143}{0.1808} = 1.1852$
$RRW_3 = \frac{0,2143}{0,2143\text{-}0,2156} = \frac{0.2143}{0.0013} = 1.6484$	$RRW_{10} = \frac{0.2143}{0.2143\text{-}0.1797} = \frac{0.2143}{0.0345} = 6.2115$
$RRW_4 = \frac{0,2143}{0,2143\text{-}0,0728} = \frac{0.2143}{0.1415} = 1.5144$	$RRW_{11} = \frac{0,2143}{0.2143\text{-}0.0236} = \frac{0.2143}{0.1907} = 1.1237$
$RRW_5 = \frac{0.2143}{0.2143\text{-}0.1319} = \frac{0.2143}{0.0824} = 2.6007$	$RRW_{12} = \frac{0.2143}{0.2143\text{-}0.0028} = \frac{0.2143}{0.2115} = 1.0132$
$RRW_6 = \frac{0.2143}{0.2143\text{-}0.0023} = \frac{0.2143}{0.212} = 1.0108$	$RRW_{13} = \frac{0.2143}{0.2143\text{-}0.0397} = \frac{0.2143}{0.1746} = 1.2273$
$RRW_7 = \frac{0.2143}{0.2143\text{-}0.0378} = \frac{0.2143}{0.1765} = 1.2141$	$RRW_{14} = \frac{0.2143}{0.2143\text{-}0.0927} = \frac{0.2143}{0.1216} = 1.7623$

Based on the results of RRW, it is known that five sub-risks produce the highest value based on risk indicators, namely Scattered into categories. $RRW_3$$RRW_{10}$ Italic font, i.e., Image blur, i.e., dirty and i.e. $RRW_5$$RRW_{14}$ RRW_4*Font* thickness.

Critical Risk Management

Critical risk handling is limited to risks with the highest RTW value in each aspect of trouble in the cause of the Newspaper's failure. Essential risk determination is carried out on the recommendation of PT. XYZ by considering all possibilities, both internal and external aspects of PT. XYZ. The risk-handling process is divided into three groups: triggers, what options should be done, and what plans should be made.

Table 7. Critical Risk Response to the Causes of Rejec Newspaper

Risk Response	Trigger	Likelihood	Contingency Plan
Scattered Ink	1. Excess filling of ink. 2. There is no setting on the ink thickness. 3. Color ink settings that have not been applied.	1. Reduce risk. 2. Risk aversion.	1. Have a dose when filling ink. 2. Designing SOPs at the time of ink filling. 3. Train the use of SOPs when filling ink. 4. Apply SOPs when filling ink.
Italic font	1. Improper laying of the Plate. 2. The margin results are italicized. 3. Ill-fitting paper settings. 4. Improper plate size.	1. Risk aversion.	1. Making tops at the time of laying the Plate. 2. Check the size of the Plate used with company standards. 3. Perform *Quality Control* of printouts.
Image blur	1. Plates are placed obliquely.	1. Reduce risk. 2. Risk aversion.	1. Provide special training at the time of laying the Plate.

	2. Oblique paper laying. 3. Poorly fitting color regulations. 4. Uncleaned Plate. 5. Overpressed Plate.		2. Apply machine regulations first before printing.
Dirty	1. Scattered ink residue. 2. Garbage accumulation. 3. Spilled oil/oil.	1. Transferring Risk 2. Risk Avoidance	1. Clean directly when ink or oil is scattered. 2. Implement a cleanness picket after production is complete.
Font Thickness	1. Machine adjustment at the beginning of the mold. 2. The engine suddenly shuts down. 3. Shifting plates.	1. Transferring Risk 2. Risk Avoidance	1. Laying paper fails at the beginning of printing. 2. Locking the end of the Plate.

Table 7 Critical Response to Causes Newspapers fail to show the handling of the risk response. Table 14 shows that there are 18 triggers of critical risks, three possible handling of critical risks, and 13 contingency plans that can be carried out against essential risks that may occur.

DISCUSSION

After calculating the p-chart, in January, there was a proportion of failures outside the UCL line on the p-control map; in January, on days 12, 15, 16, and 20, there was a proportion of failures outside the LCL line on day 19 so it can be said that the process was still not under control. In February, on days 4, 15, 16, 23, and 27. [12] a proportion of failures are outside the LCL line on the day, so it can be said that the process is still not under control. in March on the 20th, 21st and 28th days. a proportion of failures are outside the LCL line on days 3 and 13, so it can be said that the process is still not under control. In April, on days 15 and 27, there was a proportion of failures outside the LCL line on days 8 and 21, so it can be said that the process was still out of control. in May on the 14th and 19th days. there is a proportion of failures outside the LCL line on day 21, so it can be said that the process is still not under control [26].

[30] using the same method on bakery products has concluded the results of quality control measurements on CV. XYZ Magetan is still within reasonable limits, but there needs to be an improvement action, especially the number of rejections from bread. The average bread is rejected monthly, reaching 6.01% of the total produced [31]. The incidence of the cause of rejection is analyzed through risk management. Risk management measurement uses Risk Breakdown Structure (RBS) and Fault Tree Analysis (FTA) methods. Risk management results are known as the five risks that cause bread rejection. Namely, with the addition of LPG purchases, bread is broken (contents coming out and even leaking), the appearance of bread toppings is not neat, incompletely burning, and bread does not rise evenly when opened. After conducting a Risk Breakdown Structure analysis of the risk of newspapers that failed in this study, the results of risk identification using the Risk Breakdown Structure found three risk indicators with 14 sub-risks [21]. Then, continuing with the FTA, it is known that there are 18 triggers of critical risks, three possible handling of critical risks, and 13 contingency plans that can be carried out against essential risks that may occur. Research on 22 production processes in newspapers showed there are five types of defects, namely defects of blurred prints, dirty prints, not registers, and folded and torn newspapers, with a sigma level obtained of 3.92 with an average damage rate of 7760 for one million production (DPMO). The Fishbone diagram analysis shows that the

factors causing defective products come from machine, material, and human factors. Proposed improvements are made by taking preventive and corrective measures to reduce faulty products and improve product quality [32].

CONCLUSION

Based on the calculations, the results of the analysis of Quality Control using the P-Chart control map are known to be the results of printing newspapers from January to May 2022 experiencing control maps beyond the control limit. Risk Breakdown Structure from the risk of causing newspapers to fail, The results of risk identification using the Risk Breakdown Structure show three risk indicators: machinery, labor, and the environment. With 14 sub risks, namely Untidy Images, Dirty Writing Results, Scattered Ink, Font thickness, Image blur, Engine off, Unsatisfactory print results, Paper size does not fit, Paper thickness, Font italics, Stacking, Newspaper damp, Garbage piled up and Dirty. The results of the calculation of Fault Tree Analysis are known. Five sub-risks produce the highest value based on risk indicators: Scattered Ink, Italic fonts, blurry images, dirty, and font thickness. Critical risk determination is carried out on the recommendation of PT. XYZ by considering all possibilities, both internal and external aspects of PT. XYZ.

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