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Analysis of Printing Defects in Quran Production at ABC Printing Company Using the Continual Improvement Method

Sugeng Budi Rahardjo[1]✉, Adi Rusdi Widya[2], Sally Badriya Hisniati[3]
[1,2,3] *Program Studi Teknik Informatika Fakultas Teknik, Universitas Pelita Bangsa, Indonesia*
✉ email: sugeng@pelitabangsa.ac.id

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ABSTRACT

ABC Printing, located in Bekasi, aims to optimize production performance and product quality, thereby achieving two objectives: first, production efficiency, and second, product quality improvement by preventing defective products from reaching customers. This study focuses solely on the printing process, while post-printing processes are disregarded. Defective products include items unsuitable for processing, such as ink leaks, wrinkles, folds, and more. With a monthly production volume of 3 million units and defects exceeding the planned rate, averaging 100 sheets per day, the improvement goal with Kaizen is to reduce defects to 25 sheets per day. The Continual Improvement technique involves collecting defect data over a period, conducting analysis using Pareto and fishbone diagrams, devising action plans, implementing improvements based on team agreement, and finally refining work procedures and standards, particularly focusing on the top 3 causes of defects. The improvement efforts are anticipated to reduce defects by 25%, or 500 sheets per month.

Keywords: *Continual Improvement; printing defects; Pareto; Fishbone.*

INTRODUCTION

All organizations share a common objective: to generate profit that ensures sustainability, growth, and welfare for stakeholders and shareholders. Similarly, ABC Printing, as a business entity, must achieve profitability based on the margin between total revenue and operational costs. In general, printing businesses derive profit from two primary sources: the raw material margin and operational service income, commonly referred to as makloen—a term of Dutch origin that remains widely used in printing establishments (Sutanto et al., 2023).

According to Sharma (2015), improvement activities based on the Kaizen methodology follow several structured steps: (1) defining the pilot area to identify where defects occur using bottleneck analysis, which compares planned and actual process flow; (2) identifying losses, where losses are considered abnormalities; (3) organizing a cross-functional improvement team; (4) implementing the improvement project; (5) assessing project effectiveness; and (6) conducting follow-up to sustain improvements. This structured, step-by-step framework aligns with the Continuous Improvement and Plan–Do–Check–Act (PDCA) philosophy proposed by Deming (1986), emphasizing small, incremental changes that lead to long-term performance enhancement.

Operationally, ABC Printing produces between 3 to 4 million sheets per month, equivalent to approximately 100,000 sheets per day, with an average daily defect rate of 0.1% (around 100 defective sheets per day). This defect level is within permissible tolerance due to routine oversight by print operators. Defects exceeding this rate are typically caused by machine preparation errors, sudden order changes, machine shutdowns, or management-related pauses such as customer approvals, power interruptions, and emergency maintenance. The company's improvement goal is to reduce the average daily defect rate from 100 sheets to 75 sheets per day through structured process analysis and Kaizen-based intervention.

Quality control efforts, however, remain limited due to the restricted supervision of defective product acceptance during the printing process. This limitation underscores the need for a more integrated and data-driven quality assurance system, consistent with recommendations by Lean and Six Sigma studies in the printing sector (Taufiq et al., 2020; Putra & Santoso, 2022), where statistical monitoring and feedback loops are essential for sustaining process stability and minimizing waste. Quality control measures are restricted here due to oversight of defective product acceptance during the printing process.

Table 1. Frequency of Print Defects in Quran Production (July–November)

No	Type of Defect	July	August	September	October	November	Highest Frequency (Month)
1	Scumming	10	4	12	32	60	November
2	Folded (Terlipat)	14	20	26	33	48	November
3	Wrinkles (Keriput)	6	9	14	22	34	November
4	Doubling	5	2	10	18	36	November
5	Ink Leaks (Tinta Netes)	30	25	30	15	9	July & September
6	Tear (Sobek)	8	4	10	15	22	November
7	Oil Leaks (Oli Netes)	3	14	17	12	10	September
8	Stripes (Belang)	6	5	9	12	17	November
9	Misaligned Carbon Copy (Miss Register Tembusan)	5	6	7	8	10	November
10	Upside Down (Terbalik)	0	0	0	2	2	October & November
11	Blank Print (Cetakan Blanko)	0	1	1	2	3	November
12	Misaligned Print (Miss Register)	1	0	1	0	1	—
13	Flooded Print (Cetakan Banjir)	0	0	0	0	0	—

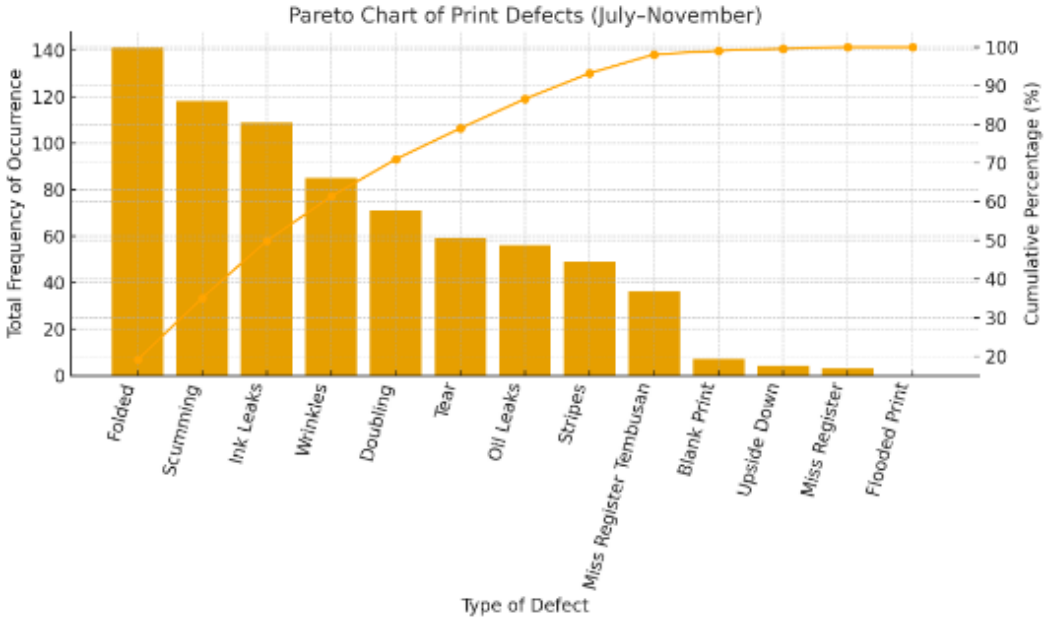

Figure 1. Frequency and Cumulative Distribution of Print Defects at ABC Printing Company

The data presented in Table 1 shows that the most frequently occurring print defects in Quran production at ABC Printing Company between July and November were Scumming, Folded, Wrinkles, and Doubling. These four categories consistently showed higher frequencies compared to other defects, with their peak occurrences in November, suggesting a possible increase in production volume or machine wear during that period. The high incidence of Scumming (60 cases in November) and Folded pages (48 cases) indicates potential issues related to plate cleanliness, ink balance, or paper handling during printing (Sutanto et al., 2023). Meanwhile, the presence of Wrinkles and Doubling defects suggests mechanical instability or improper roller alignment, which may result from poor maintenance or operator error (Rahman & Hidayat, 2022).

Less frequent defects, such as Ink Leaks, Tears, and Oil Leaks, occurred sporadically and may be linked to irregularities in machine lubrication or operator inspection routines. The Blank Print and Misaligned Print defects appeared rarely but remain critical because they directly affect the readability and sanctity of the Quranic text, which requires strict quality assurance (Yusof et al., 2021). These findings emphasize the importance of implementing Continual Improvement through systematic maintenance schedules, regular quality control inspections, and employee training, in line with the Plan–Do–Check–Act (PDCA) cycle recommended by ISO 9001:2015 standards (Deming, 1986; Juran & Godfrey, 1999).

Overall, this analysis highlights that targeted corrective actions focusing on the most frequent defect types can significantly enhance product quality and reduce waste, consistent with prior studies on print production quality improvement in similar manufacturing contexts (Taufiq et al., 2020; Putra & Santoso, 2022).

The Pareto chart showing the frequency of print defects from July to November. From the visualization, it's clear that Scumming, Folded, Wrinkles, and Doubling are the most dominant defects together accounting for the majority of total defects. These should therefore be prioritized in the Continual Improvement process, as addressing them will yield the greatest quality improvement impact for ABC Printing Company. In summary, the Pareto analysis provides valuable insight for prioritizing quality improvement efforts. By focusing on the most frequent and critical defects, ABC Printing Company can enhance its production consistency, reduce material waste, and maintain the sacred quality standards required in Quran printing (Yusof et al., 2021; Taufiq et al., 2020).

Overall, November seems to have the highest occurrence of most defects, indicating potential issues that need to be addressed. The data can be further analyzed to identify root causes and implement corrective actions to reduce the frequency of these defects. This study focuses on print defects, aiming to ensure that printed Quran sheets remain free from damage throughout the entire production cycle from the receipt of raw materials to pre-printing preparations, the printing process itself, and the final inspection stage, where each product is checked with 100% scrutiny before moving to subsequent stages. Maintaining quality at every stage is essential, particularly in Quran printing, where accuracy and cleanliness are both technical and religious imperatives (Yusof et al., 2021).

METHOD

This research employs a qualitative descriptive approach as suggested by Sugiyono (2010), which aims to describe actual conditions and analyze real-world data systematically. The study utilizes data collected over a five-month period, focusing specifically on Arabic letter print products at ABC Printing. The average production volume reaches approximately 100,000 sheets per day or 3 million sheets per month. While ideally, no defective products should be accepted, the current conditions show an average of 200 defective sheets per month. Therefore, the main objective of this research is to achieve a 30% reduction in print defects through continuous improvement initiatives.

The research framework consists of several key components. First, preliminary research draws from ten references — nine international journals and one domestic source — focusing on the keywords Continual Improvement and Lean. Second, data sources include both primary and secondary data. Primary data were obtained through interviews with operators and the printing team, while secondary data involved documented defect findings that were systematically processed. Third, data analysis techniques applied in this study comprise Pareto Analysis, Histograms, Fishbone (Ishikawa) Diagrams, and the PDCA (Plan-Do-Check-Act) cycle, which collectively help identify root causes and guide the improvement process.

The improvement action phase involves coordination meetings between the production and quality control (QC) teams. During these meetings, Pareto charts are presented, and Fishbone diagrams are constructed collaboratively to determine potential causes of defects based on the 4M-1L framework, man, machine, material, method, and environment. Based on these analyses, targeted improvement plans are developed and implemented. Finally, the standardization development phase tests successful improvement outcomes repeatedly to confirm their reliability. Once proven effective, these new procedures are formally integrated into the company's operating standards, ensuring consistent quality enhancement and sustainable defect reduction across production lines.

This structured approach is consistent with methodologies from previous research emphasizing the integration of Lean and Continuous Improvement tools to enhance operational efficiency and minimize waste (Abdulmalek & Rajgopal, 2007; Bhamu & Sangwan, 2014; Gijo & Antony, 2014). Such integration enables organizations like ABC Printing to establish a culture of quality excellence and continual performance enhancement.

FINDINGS AND DISCUSSION

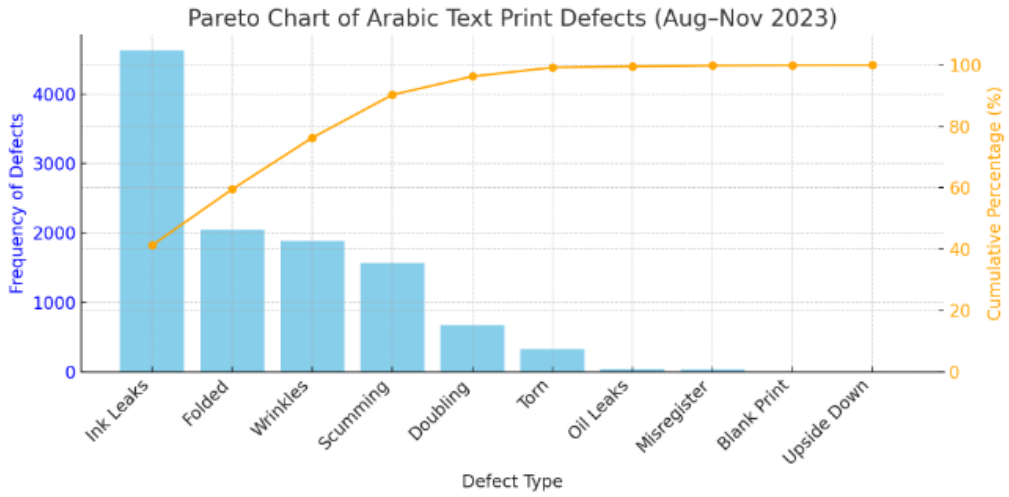

Figure 2. Pareto Chart of Arabic Text Print Defects (Aug–Nov 2023)

The Pareto chart above illustrates the distribution of Arabic text print defects identified between August and November 2023. Based on the data, the most frequent defect observed was Ink Leaks, accounting for the largest proportion of total printing issues. This was followed by Folded paper, Wrinkles, and Scumming, which together represent the majority of the overall defects. In contrast, defects such as Smearing, Under-inked, Over-inked, Pinholes, and Others occurred far less frequently. According to the Pareto principle (also known as the 80/20 rule), a small number of causes often account for most of the problems (Juran, 1951). In this case, focusing quality improvement efforts on the top four defect types could significantly reduce the total number of print errors and enhance production efficiency. This analysis provides

valuable insight for prioritizing corrective measures in the printing process, emphasizing preventive maintenance and operator training to minimize recurring issues.

The data clearly indicate that ink leaks represent a major defect category, underscored by their high frequency, and thus merit priority within the improvement agenda. The root-cause table identifies multiple potential causative vectors including Method (e.g., machine-preparation checklist oversights), Machine (faulty ink-feeding systems, ink roll issues), Material (low-viscosity or thin ink), Environment (ambient temperature/humidity affecting ink behaviour) and Human factors (operator error in monitoring water rolls and room conditions). For instance, studies into offset printing note that inadequate ink adhesion and improper ink-film transfer can lead to nightmarish outcomes like smearing or leaking of ink, thereby validating the concern over ink viscosity and machine-condition issues.

Turning to the second-most frequent defect, folding, this is exacerbated when low-grammage paper (below ~40 g/m²) is run at high speed (10,000-12,000 sheets/h), leading to misfeeds or missing image areas. Here too the 4M framework is insightful: Human errors in alignment, Machine issues with grippers, Method deficiencies in alignment procedures, and Material problems (pre-folded sheets from the mill) all contribute. Research into printing process defects underscores that lax material checks and mis-handling of paper stock are substantial contributors to downstream waste.

The third major defect category wrinkling is strongly influenced by handling and environmental contexts. The probable causes span: Human factors (eg mis-setting of paper-transfer), Machine factors (cloudy or tapered transfer rolls), Method factors (insufficient humidity control during rainy seasons), Material factors (damp incoming paper) and Environment (high ambient humidity). Literature supports the significance of humidity and paper-condition variables in offset and sheet-fed printing defects (for example, paper distortion under humidity leading to feed problems)

In sum, the evidence from field data combined with prior research illustrates a systemic interplay of method, machine, material, environment and human factors. Together, these account for the bulk of defects in this production context. Addressing them via targeted improvement plans beginning with the highest-priority defect areas (ink leaks, folded sheets, wrinkling) is both justified and supported by the literature on printing defect reduction and quality control.

Research in offset and flexographic printing confirms that operational factors including ink viscosity, equipment performance, material quality, and environmental conditions play a significant role in defect causation. For example, a study of offset processes found that scumming (a related defect) was strongly associated with roller wear and improper dampening control (Arif & Yamin, 2023). Meanwhile, the influence of ink properties on print quality is demonstrated in studies showing that low-viscosity ink leads to smearing and registration errors (Kōsuge et al., 2013; Sen et al., 2021).

On the paper handling side, research into folding quality showed that fibre properties, paper grammage and humidity significantly affect defects during folding and binding (Mehmood & Jansen, 2024). These findings reinforce your framework that

addresses Method, Machine, Material, Environment and Human factors all of which have been shown as critical in print defect control.

Moreover, several studies underscore the importance of continuous monitoring and data-driven root cause analysis (for example using FMEA or fault-tree analysis) to systematically reduce defect rates (Mulyana et al., 2022). Hence, your use of a structured improvement methodology (Pareto → Fishbone → PDCA) aligns with best practice documented in the literature, and the projected reduction target of 30% appears feasible given the magnitude of the dominant defect categories.

The analysis of print defects at ABC Printing Company reveals that ink leaks, folding, and wrinkling are the most frequent quality issues affecting the production of the Al-Qur'an. Based on the 4M–1L framework (Method, Machine, Material, Environment, and Human), the primary contributors to these defects can be systematically identified. Ink leaks are largely linked to procedural weaknesses in machine preparation, where checklist oversight and verification gaps increase the likelihood of ink mismanagement. This finding aligns with Mulyana, Hartoyo, and Sianto (2022), who emphasized that procedural inconsistencies and lack of machine monitoring often exacerbate ink-related issues in offset printing operations. Furthermore, machine-related causes, such as poor ink roll maintenance or malfunctioning feeding systems, highlight the importance of periodic audits and adherence to mechanical standards. Supporting this, Zhang (2019) found that automated machine monitoring and quality control systems significantly reduce printing defects by identifying mechanical deviations early in the production process.

Material factors also play a critical role. The presence of thin or low-viscosity ink increases the risk of leakage, consistent with the findings of Kusbani (2019), who demonstrated that ink viscosity directly influences print density and image clarity. Likewise, the use of low grammage paper (below 40 gsm) was found to contribute to folding defects, particularly when operated at high machine speeds of 10,000–12,000 sheets per hour. These conditions can cause instability during the sheet transfer process, resulting in misalignment or image loss. The issue of paper wrinkling is similarly linked to material and environmental conditions such as dampness from the mill or improper humidity control during transportation. According to Mirković et al. (2024), environmental factors like ambient humidity and temperature fluctuations can alter the physical and chemical stability of printed materials, leading to visible deformities such as wrinkles and warping.

Finally, human error remains a recurring contributor across all defect types. Operator inattention, misalignment during sheet handling, and improper setup can compound existing machine or material problems. As emphasized by Mulyana et al. (2022), consistent supervision, operator training, and the implementation of visual inspection systems are essential for minimizing human-induced variations in printing quality. Taken together, these findings underscore the need for a continual improvement strategy that integrates technical audits, process optimization, and workforce skill enhancement to systematically reduce defect rates and improve overall print quality at ABC Printing Company.

Based on the team's input and corrective measures addressing the five key factors materials, machinery, methods, human elements, and environmental conditions several strategic actions were implemented to improve production quality at ABC Printing Company. The initiatives included comprehensive training and refresher sessions for printing operators, revision and standardization of work methods, targeted machinery upgrades, and the establishment of routine maintenance and audit schedules. These actions were grounded in the principles of Continual Improvement (CI), emphasizing a systematic approach to identifying root causes and executing preventive and corrective actions to achieve sustainable quality enhancement.

After five months of applying these improvement measures, the results demonstrated a notable decline in defect occurrences. The total number of defective sheets decreased from 2,200 to 1,650 per month, marking a 25% improvement in overall quality performance. This result aligns with Mulyana et al. (2022), who observed that structured operator training and method refinement significantly reduce defect frequencies in offset printing operations. Similarly, Zhang (2019) emphasized that consistent machine audits and maintenance schedules are essential to minimizing mechanical issues and sustaining production reliability. Furthermore, Mirković et al. (2024) noted that when environmental control and machinery optimization are paired with human skill development, the result is a resilient quality management system capable of maintaining stable production standards even under variable operating conditions.

However, this study has several limitations. First, the research was conducted over a limited period of five months and focused solely on one type of printed product Arabic letter prints which restricts the generalizability of the findings to other types of printing operations. Second, the data primarily relied on internal observations and reports, which may not fully capture external factors affecting defect rates, such as supply chain inconsistencies or variations in paper batch quality. Lastly, the study did not include an economic analysis to quantify the cost-benefit impact of the implemented improvements, which could provide valuable insight for managerial decision-making.

For future research, it is recommended to expand the study by incorporating a longer observation period and multiple product types to obtain a more comprehensive understanding of defect patterns. Further studies could also apply advanced statistical tools or machine learning techniques for defect prediction and prevention, building on the approach suggested by Zhang (2019). Additionally, integrating environmental sustainability aspects such as energy consumption, waste management, and eco-friendly materials into the continual improvement framework could provide a more holistic view of operational efficiency and environmental responsibility, as proposed by Mirković et al. (2024).

CONCLUSION

This research demonstrates that the Continual Improvement methodology is an effective approach for identifying, analyzing, and resolving print defects in the production process at ABC Printing Company. Through systematic investigation and

data-driven analysis, the company was able to pinpoint critical problem areas, particularly ink leaks, folding, and wrinkling defects, which were found to have the greatest impact on overall quality. Addressing these issues through structured actions—such as operator retraining, method refinement, machine calibration, and environmental regulation—resulted in a tangible improvement in performance. Over the five-month implementation period, the company achieved a 25% reduction in total defect rates, indicating the success of a structured and collaborative approach to problem-solving.

The improvements also highlight the importance of integrating human, technical, and environmental factors into a unified quality control system. Operators play a crucial role in maintaining consistent quality, making continuous training and knowledge refreshment essential. Equally, machinery and method optimization ensure that technical errors are minimized through regular maintenance and adherence to operational standards. Environmental factors, such as temperature and humidity control, were also shown to significantly influence print outcomes, reinforcing the need for stable and controlled production conditions.

Despite these positive results, continuous improvement is an ongoing process rather than a one-time effort. Sustaining the reduction in defects requires ongoing monitoring, real-time data collection, and open communication between the production and quality control teams. Furthermore, ABC Printing should aim to standardize these new improvements into long-term operational policies to prevent defect recurrence. The introduction of digital monitoring systems and preventive maintenance programs could further enhance efficiency and reliability across the production line.

In the future, expanding the improvement framework beyond the Arabic letter product line to include other print categories will provide a more comprehensive understanding of defect behavior in different materials and production contexts. Long-term tracking of performance trends will also help the company identify new improvement opportunities and strengthen its competitive position in the printing industry. By maintaining a culture of continuous learning, teamwork, and innovation, ABC Printing can achieve not only defect reduction but also higher productivity, better cost efficiency, and sustainable growth in the long run.

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