ROOT-CAUSE-ANALYSIS OF RECURRING FLOUR PACKAGING PRINTING DEFECTS UTILIZING QUALITY CONTROL TOOLS

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ABSTRACT: *This study aims to conduct a root-cause analysis of recurring flour packaging printing defects using quality tools. The quality of packaging materials plays an important role in ensuring product information, customer communication, and traceability in the Food Manufacturing Industry. Printing Defects caused by the printer itself may lead to additional manufacturing costs, customer dissatisfaction, and even damage to the brand's reputation. Therefore, it is very important to identify the root cause of these recurring defects and implement effective countermeasures. The research methodology involves analyzing one year of data from January 2022 to December 2022 with specific emphasis on the Domino Printer Equipment and analyzing all the defects using the Pareto Chart and Fishbone Diagram. The outcome of the analysis identified the unclear print and skipped printed ticket numbers are the primary causes of rejection. The study concludes that utilizing quality tools helps identify and prioritize defects, enabling the implementation of corrective actions and process improvements.*

Keywords: Fishbone Diagram, Pareto Chart, Quality Tools, Printing Defects, Manufacturing Technology

1. INTRODUCTION

The flour manufacturing industry aims to meet the customer's needs, and a high-precision color picture to publish with good quality printing is required. The quality of the product is achieved by minimizing defects and reducing downtime. In many cases, failures occur during the processing, and some defects can be found in flour packaging quality. The implementation of quality tools (QTs) and methodologies is necessary to reduce defective items, thus reducing the overall quality costs [1].

Constant changes to customer needs, new markets, innovations, and other external factors, encourage organizations to continuously improve the quality of their current process and develop new processes to meet market trends [2]. The importance of quality measurement and improvement has grown over time in the investigation of continuous product and service improvement [3]. The high level of competitiveness between business environments has certainly intensified the marketability of products to meet the needs and wants of customers. To capture and sustain customers' purchase intention, packaging has become an essential tool in the way business organizations conduct their sales promotion. The strategic use of packaging can increase the sales and market share of a particular product and interestingly, even defray and decrease the company's market and promotional costs as more and more customers are attracted to their product [4]. Hence, the quality of materials used in packaging and its associated printing is of utmost importance. However, defects in the printing that are caused by the printer itself can result in a significant impact on both the manufacturers and consumers as it may lead to additional manufacturing and raw materials costs, customer dissatisfaction, product recalls, and damage to brand reputation. Therefore, it is important to identify the root causes of this recurring defect and implement effective countermeasures to prevent or lessen its recurrence.

Quality improvement is a continuous process that assumes the implementation of quality control tools. Quality is very important in today's competitive environment. Quality control tools can be applied in product development, production, and marketing. Quality control is aimed to satisfy the customers by delivery of defect free products [5].

The most commonly used quality tools are the Pareto Chart and Fishbone diagram. It is a widely adopted approach in problem-solving that aims to identify the cause of a certain issue. Pareto Analysis is known as an 80/20 rule which suggests that 80% of the effects come from 20% of the causes, it is a statistical approach that helps prioritize the most significant factors contributing to the problem [6]. Also known as the Ishikawa or the cause-and-effect diagram, the fishbone diagram is a tool that helps to identify the root causes of a problem or its effects. The diagram helps to identify and categorize the possible causes of a problem by breaking down the problem into smaller subcategories [6].

Nowadays, SQC techniques are utilized both in industry and academe settings. Some of the applications in the industry setting included identifying causes of defects in PVC pipe production [7] and shoe production [8], cost and project monitoring in a construction project [9], improvement of quality of weights of bags in feed production [3], and many others. On the other hand, some of the applications of SQC techniques in academic settings included the evaluation of self-learning modules for basic education [10], the assessment of the performance of graduates in licensure examinations for teachers [11], and many others.

In this study, quality tools such as Pareto Analysis and Fishbone diagram have been applied to the root cause analysis of recurring packaging printing defects will benefit the company. It will help provide visualization of the problem, its causes, and their relationship. It will facilitate cross-functional collaboration and sharing of knowledge among the stakeholders involved in the Flour Manufacturing, particularly in the Packing Section.

2. MATERIALS AND METHODS

2.1. Data gathering

This case study is conducted in Flour Manufacturing in the Philippines. It is a state-of-the-art manufacturing plant where the processes are mostly automatic. In the past years, there has been a significant increase in machine downtime

related to packaging printing that may pose a potential increase in the rejection of finished goods due to unclear printing, errors in code series, etc.

The Automatic Packing line process has a capacity of 14 bags per minute which comprises of automatic packing of 25kg flour per bag, automatic closing of bags using sewing machines, check weighing and metal detections, and printing of codes as the final process.

In the 2022 records from the Engineering and Maintenance Department, printer-related downtime accounts for 1,264 minutes which is 9.49 % of the total downtime. Domino Printer is in the third spot in the top equipment downtime contributor (see below Figures 1 and 2) and that will account for approximately 17,696 rejected bags at 14 bags/minute operation rate. Addressing this problem may lessen the rejection due to errors in code printing and the possibility of packaging quality-related problems with the finished product. This problem may be caused by sensor and system programming malfunctions which have been further investigated and analyzed in this case study using quality tools.

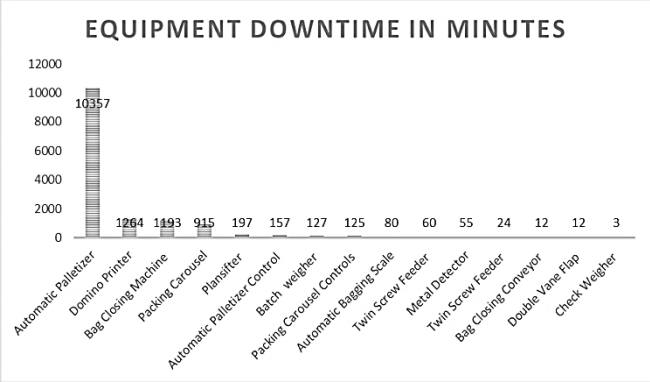


Figure 1. January to December 2022 Equipment downtime in minutes.

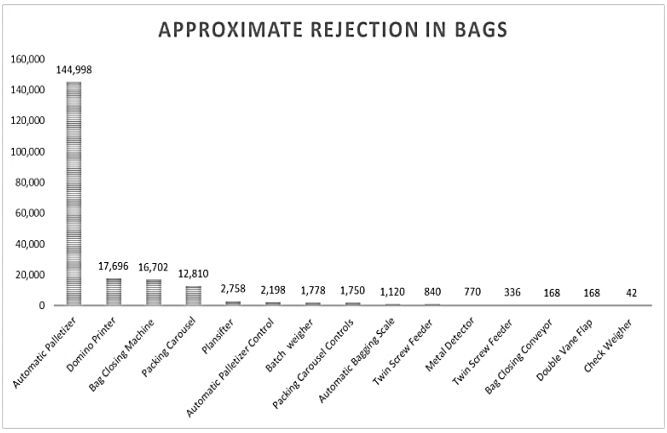


Figure 2. January To December 2022 Approximate Rejection In Bags Based On The Equipment Downtime.

2.2. Pareto Chart

Pareto analysis serves as a straightforward tool for identifying and prioritizing defects and their frequency. A comprehensive analysis of printing-related issues encountered within a flour packaging facility is conducted. By examining one year of data from January 2022 to December 2022, the study investigates equipment downtime across all machines, with a specific focus on the Domino Printer—a piece of vital equipment responsible for printing codes on flour packaging. Results indicate that the Domino Printer ranked third among the top contributors to downtime, directly impacting the rejection of packaging materials. Furthermore, the paper explores the categorization of problems arising from Domino Printer downtime based on their respective types. To assess the most probable defects, data was collected and presented in Table 1.

Table 1. January to December 2022 problems associated with Domino Printer Downtime, its frequency and duration in minutes.

Equipment	Frequency	Duration (mins)
Domino Printer,Ax350	88	1264
Defective domino sensor	2	86
EHT Deflection tripped-off	4	66
Fault/ Warning Indication cause by uncover the code for the sticker	4	77
Skipping of printed ticket number	8	82
Slow gutter dry	1	29
Unclear print	69	924
Grand Total	88	1264

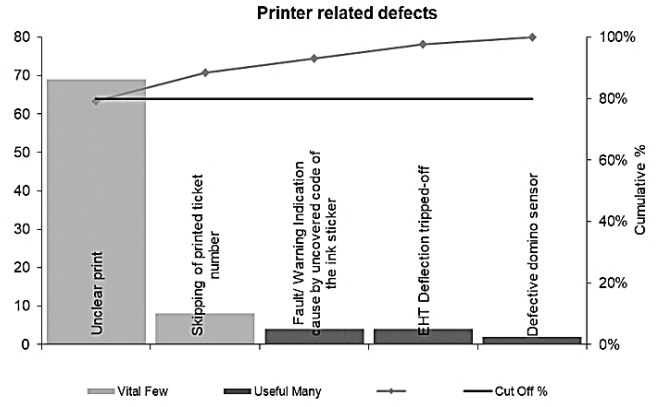
2.2. Fishbone Diagram

Fishbone Diagram (also known as an Ishikawa or Cause-and-Effect Diagram) to determine the root causes of the Domino Printer downtime. The study proceeds by conducting root cause analysis using a fishbone diagram of causes with the highest frequency. As shown in Table 1, unclear printing and skipping of printed ticket numbers have the highest frequency.

3. RESULTS AND DISCUSSION

3.1. Pareto Analysis of Domino Printer Downtime

Upon conducting a Pareto analysis on Table 3, notable observations reveal that the primary cause of rejection is Unclear Printing of codes in the packaging, accounting for a substantial percentage of 79.3%. Additionally, the issue of skipped printed ticket numbers contributes 9.2%, resulting in a cumulative percentage of 88.5% - see the line that starts from the bottom left corner and ends in the upper right corner. These identified factors constitute the vital few contributors responsible for the effects and subsequent rejection as shown in Figure 3.



	Cumulative Percentage Cutoff:		80%
1	Unclear print	69	79.3%
2	Skipping of printed ticket number	8	88.5%
3	Fault/ Warning Indication cause by uncovered code of th	4	93.1%
4	EHT Deflection tripped-off	4	97.7%
5	Defective domino sensor	2	100.0%

Figure 3. Pareto Chart for Domino Printer Downtime

As shown in Figure 3, the top two factors encompass a substantial 88.51% of the total. Defects that fall inside 80% of the total occurrence are further analyzed through a fishbone diagram and propose countermeasures to address the defects.

3.2. Root cause analysis using a fishbone diagram.

The Pareto Analysis outcomes reveal the following issues and their respective cumulative percentages: Unclear print (79.3%), Skipping of printed ticket number (88.5%), Fault/Warning Indication due to uncovered code of the ink sticker (93.1%), EHT Deflection tripped-off (97.7%), and Defective domino sensor (100.0%). Subsequently, a Fishbone Diagram analysis was conducted on the two most critical issues, which are unclear print (Figure 4) and skipping of printed ticket numbers (Figure 5).

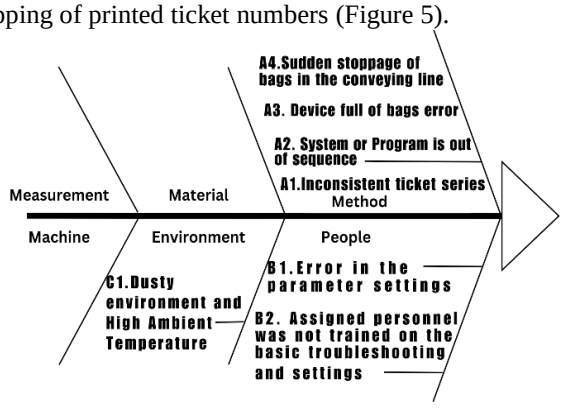


Figure 4. Fishbone diagram for Unclear Print

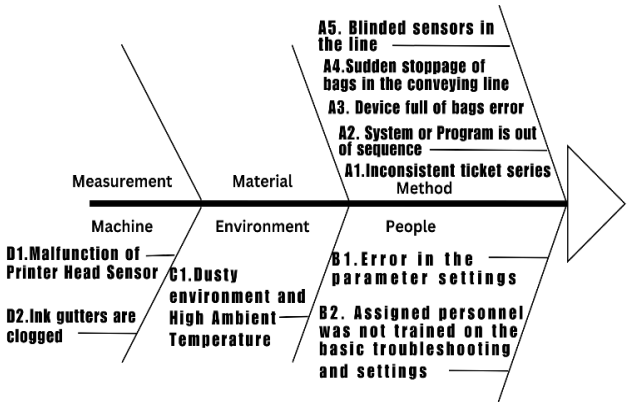


Figure 5. Fishbone diagram for Skipped Printed Ticket Number

Fishbone Diagram Categories used in this study are discussed below:

1. Method – system processes and procedures that possibly contribute to the defects which in this case involved inconsistent ticket series in the system and multiple errors such as the system or program being out of sequence, device full of bags, and sudden stoppage of bags in the conveying line.
2. Material – refers to the raw materials and components used in the production processes that could contribute to defects. In this study, there are no identified material-related causes.
3. Measurement - tools and techniques used for quality control and measurements.
4. Machine - equipment, and machinery used in the production process. As shown above, the root causes of the unclear printing associated with the machine are a Malfunction of the Printer head sensor- the sensor that detects the product in the conveying line and triggers the printing head of the Domino Printer to start the printing and clogged ink gutters – this gutter is responsible for the distribution of ink in the system.
5. Environment – The external factor that contributes to the defect is the dusty environment with high ambient temperature. This would lead to the malfunction of sensors and electrical components.
6. People–man–man-power or human-related factors that contribute to the defects are errors in the parameter settings because of lack of training of the assigned personnel.

Table 2. Proposed solution for each cause

Counter Measures	
METHOD	
A1. Inconsistent ticket series	1. Conduct testing on the Machine prior to start-up of operations. 2. Conduct servicing and Testing of the Machine every 3rd shift (10pm-6am) during no scheduled operations. 3. Re-check recipe or parameter settings of the machine prior to start of operations. 4. Adjust Manufacturer's Preventive Maintenance schedule from semi-annual to quarterly.
A2. System or Program is out of sequence	
A3. Device full of bags error	1. Conduct servicing and Testing of the sensors every 3rd shift (10pm-6am) during no scheduled operations. 2. Due to the dusty environment in the packing area, operators and personnel in-charge should conduct cleaning on the sensors and reflectors in between shifts to avoid accumulation of flour dust in the sensors.
A4. Sudden stoppage of bags in the conveying line	
A5. Blinded sensors in the line	
PEOPLE	
B1. Error in the parameter settings	1. Re-check recipe or parameter settings of the machine prior to start of operations. 2. Create work instruction and print the standard parameters of the system and have it available on-site for the operator's reference.
B2. Assigned personnel was not trained on the basic troubleshooting and settings	1. Conduct refresher troubleshooting training on the operators and personnel in-charge. 2. Conduct weekly meeting between Engineering and Maintenance and Production department to discuss downtime details and problem encountered during the operations.
ENVIRONMENT	
C1. Dusty environment and High Ambient Temperature	1. Follow-up packing ventilation CAPEX Project.
MACHINE	
D1. Malfunction of Printer Head Sensor	1. Adjust Manufacturer's Preventive Maintenance schedule from semi-annual to quarterly. 2. Check sensor alignment prior to start-up. 3. Purchase spare sensor.
D2. Ink gutters are clogged	1. Purchase new ink and solution cartridge. 2. Conduct flashing on the system every 3rd shift when there are no scheduled operations. 3. Purchase UPS for the printers to avoid unexpected power interruption that can cause sudden stoppage.

This data is carefully examined in the daily engineering and maintenance reports available in SAP records by the maintenance specialists assigned to troubleshoot the errors in the Domino Printer. After the fishbone diagram analysis, the following proposed solution for each cause is presented in Table 2. To reduce the reoccurrence of Equipment Downtime which will potentially affect Finished Goods Packaging Quality, corrective and preventive actions are being proposed to the stakeholders, particularly in the Production Department and Engineering and Maintenance Department.

4. CONCLUSION AND RECOMMENDATIONS

Quality tools such as the Pareto chart and fishbone diagram are utilized to illustrate the primary defects that occur with high frequency. After using the tools, the outcomes are listed below:

1. The packaging defects are identified, and the main causes are effectively prioritized.
2. Identify which category or stakeholder needs to improve and implement necessary corrective actions and process improvement to lessen the printing equipment downtime that contributes to the defect. Based on the outcomes obtained from utilizing quality tools like the Pareto chart and fishbone diagram, the following recommendations are suggested:

Based on the outcomes obtained from utilizing quality tools like the Pareto chart and fishbone diagram, the following recommendations are suggested:

1. Implement the proposed solution for each root cause. It is crucial to develop and implement corrective actions targeting each cause.
2. Establish a system to continuously monitor the effectiveness of the corrective actions and process improvements implemented. Regularly collect data on defect occurrence, printing equipment downtime, and other relevant metrics.
3. Foster open communication and collaboration among different departments and stakeholders involved in the printing process. Encourage sharing of insights, best practices, and lessons learned to enhance the overall understanding and improvement of the process. Establish regular meetings or forums to discuss challenges, progress, and potential opportunities for further improvement.

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