Quality Control Management with Six Sigma Approach to Minimize Defects in The Invitation Paper Production Process

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Abstract

This research was conducted at a printing company to analyze the quality control of invited products in CV XYZ. In the preliminary analysis carried out at CV XYZ, there are several types of defects in invitation products in the production process, namely untidy invitation folds, untidy screen-printing results, and blurred printed ink caused by machines and inaccuracies from workers. This printing house needs to look for the causative factor of the problem

and fix the quality problem and improve the quality. Quality control is carried out using the six-sigma method to identify five stages: Define, Measure, Analyze, Improve, and Control. The level of process capability based on DPMO and Sigma values shows that the average sigma value is 3.95, with possible damage of 7,612,321 products for every one million productions, where the sigma level achieved is still far from the desired target of 6 sigma and 3.4 DPMO.

Keywords
Quality Control, Quality Characteristics, Six Sigma, DPMO.

1. Introduction
CV XYZ is one of the businesses engaged in the printing industry. This business produces various products, one of which is an invitation product. In the preliminary research carried out at CV XYZ, there are several types of defects in invitation products in the production process. This printing house has a disability tolerance limit standard of 2% set by the business owner. In the production process, three defects often occur untidy invitation folds, untidy screen printing results, blurred printed ink caused by machines, and inaccuracies from workers. This printing house needs to fix the quality problems of the invitation product in the production process. Thus, during the production process, no more waste is caused, and there is no defective product output. Through quality control, the company can prevent the occurrence of faulty products. One of them is to use the six-sigma method. Six Sigma is a widely used method of identifying and eliminating defects, errors, or failures in business processes. This method focuses on performing functions that have significance for consumers(Alexander et al., 2019). In principle, according to (Makwana & Patange, 2021) (Stankalla et al., 2018), six Sigma is used to identify five stages of quality control six Sigma, namely DMAIC, including Define, Measure, Analyze, Improve, and Control.

Table 1. Number of Defective Products in Invitation Products in 2022

Moon	Sum Production/Month (Unit)	Sum Defective Products (Units)	Percentage Defective Products (%)
January	3,300	72	2.18
February	3,200	63	1.96
March	2,800	48	1.71
April	3,400	78	2.29
May	3,700	89	2.40
June	4,000	97	2.42
Sum	20,400	447	12.96
Average	3,400	74.5	2.16

Table 1 shows that the level of damage/failure to print cv XYZ invitation products exceeds the predetermined tolerance limit, an average of 2.16%. This proves that there is still a lack of quality control for the Invitation product, so it is necessary to analyze how quality control efforts with a six-sigma approach and look for the root cause of the damage level, as well as proposed repair improvements to reduce the level of damage to the product to reach zero defects. Six Sigma is a highly orderly process that helps organizations focus on developing and improving the quality of products and services to a near-perfect level. Knowing the number of defects that occur in a process can be systematically described and analyzed more deeply about how to eliminate the cause of the defect so that it will produce a product that is zero defects(Vendrame Takao et al., 2017). With the existence of defect-free products, the quality of products and the company will also increase.

1.1 Objectives
This study aims to Identify the types of defects that most often occur during the invitation-making Process, find out how good the production process is based on the level of process stability by the value of Defects Per Million Opportunities (DPMO) and Sigma Value, and Provide proposed improvements to overcome quality problems and reduce the level of product defects.

2. Literature Review

In the study(Syaichuddin, 2018), Based on the results at the defined stage, the following measure is the second operational step to improve quality in the DMAIC method. At this stage, measurements are carried out, and quality keys (CTQ) quality characteristics are recognized. This measurement stage is critical in improving quality because it can be known the state of the company from existing data so that it becomes a benchmark or basis for carrying out analysis and improvement(Chiarini & Kumar, 2021).

Six Sigma uses a business framework to realize its goals. With a reasonably high success percentage of 99.9966%, Six Sigma can become a new standard for anyone involved to improve their abilities. Making strategic changes from introducing new products, establishing further cooperation, entering new markets, and so on can be a benefit of implementing Six Sigma for companies(Gupta et al., 2020)(Nazaruddin & Septiani, 2021). The benefits of the Six Sigma Method in the defense industry can be felt optimally if its implementation is supported by top-level, solid teamwork, appropriate training programs, the latest measuring tools, and a better work ethic(Shamsuzzaman et al., 2018). In addition, a structured way of working (using the DMAIC method) and regular reviews through gate reviews carried out at the end of each phase by experts will provide a quick solution that can save a lot of time and resources. Cost Savings. The main focus of lean six Sigma is to reduce waste, and any effort will undoubtedly lead to cost savings in the business(Prakash et al., 2021).

The Six Sigma concept facilitates almost 'zero defect manufacturing' and accumulates high profits. Six Sigma's vision allows organizations to make mistakes of less than 3.4 defects per million chances (DPMO). To achieve this goal, two approaches were followed. Projects that lead to the prevention of defects should be carried out in the organization by implementing the define, measure, analyze, improve and control (DMAIC) phase(Antony et al., 2018).

According to(Syaichuddin, 2018), (Puram & Gurumurthy, 2021), and (Prakash et al., 2021), Six Sigma's concept of the ability to facilitate organizations to obtain high profits attracts many quality managers. According to(Shokri, 2017), (Puram & Gurumurthy, 2021), and (Sachin & Dileeplal, 2017), Six Sigma was first implemented in many leading companies, such as general electricity and similar signals. However, training belt-based behavior is so expensive that it prevents the implementation of Six Sigma in companies with small incomes(Shamsuzzaman et al., 2018). To address this situation, researchers and practitioners have been researching how DMAIC has implemented only the Six Sigma program in the company over the years(Yaduvanshi & Sharma, 2017)(Nazaruddin, 2022).

Defective products can be reduced if the company can reduce the number of defects in the product. The number of defective products is expected to decrease with a decrease in the number of defects. Thus, the Six Sigma DMAIC method can minimize defects and maximize the added value of a product.

3. Methods

This methodology starts with an introduction, namely preliminary surveys and literature studies, problem identification, problem formulation, research objectives, data collection, data processing, data analysis, conclusions, and suggestions. The following are the stages in the methodology of this study.

1. Introduction

The introduction consists of a preliminary survey and a study of literature. Initial surveys are activities carried out to obtain information in the data needed for research. A preliminary survey was conducted to see the field conditions of Micro Enterprises and Menegah XYZ.

2. Problem Identification

In this study, identifying problems that arise was carried out by conducting a survey directly at Micro Enterprises and Menegah XYZ. From the results of surveys about invitation products, there are defective products during the production process that will harm Micro-Enterprises and Menegah XYZ.

3. Research Objectives

The purpose of the study is used to solve or solve a problem in the research. In this study, the purpose of the study was used to analyze the quality control of invitation products that had been carried out.

4. Data Collection

This observation method is carried out by directly observing problems in the agency and collecting data needed in conducting research by conducting interviews with several workers. (Hamzah et al., 2021; Rizki et al., 2021; Tambak et al., 2022) The data collection results have several stages. The types of data and their output can be seen in Table 2.

Table 2 Stages of the Research method

Stages	Purpose	Data	Method	*Output*
Step 1.	Identifying problems, determining the type of disability that is the cause of the source of production failure and categorize product disability data.	Number of defective products	Histogram	Significant types of disability
Step 2.	Knowing whether the resulting defective product is still within the required limits	Number of defective products	Full Map (P-*Chart*)	The abundance of defective products
Step 3.	Knowing the level of achievement of product quality based on a sigma value	Number of defective products	Calculation of DPMO and *sigma* value	The degree of achievement of quality and sigma level
Step 4.	Prioritizing problems based on product defects	Product disability rate	Diagram Pareto	The highest type of product defects that will be be the focus of improvement
Step 5.	Identifying and analyzing the factors causing product defects in the production process invitation	Types of product defects	Causal Diagram (Fishbone)	Factors causing product defects
Step 6.	Provide recommendations for quality improvement proposals for factors causing accidents to improve quality product.	Factors causing disability	5W+1H (What, why, where, when, who, how)	Eliminate disability and improve product quality
Step 7.	Preventing the occurrence of product defects in the production process	Workflow	Soup	Guidelines for operational activities to process production runs smoothly

5. Results and Discussion

5.1 Production Process

has three processes for producing invitations. The invitation production process on CV XYZ is as follows:

1. Print Process This Process begins with designing the writing on the invitation using CorelDRAW software. The results of the invitation design will be printed on the inner invitation stamp using a Canon Ip2770 Printer. The design process of writing this invitation is adjusted to consumer demand.
2. Invitation Unification Process
   This process begins with preparing the raw materials needed to unite each part of the invitation into a unified whole. The raw materials required, namely: the inner and outer blank of the invitation, stiff cardboard, and fox glue. Unite the inner and outer blank of the invitation on both sides of the paper carton using glue fox neatly. The adhesive used to hold the invitation stamps and stiff cardboard together must be ensured that it has dried up. Fold the invitation into two parts according to the reference line on the invitation letter.
3. Screen Printing Process
   This process begins with making a screenprinting film design that will be printed using CorelDRAW software and a technique using deep black. The design results will be printed using the HP 107w Laser Printer on tracing paper. Pour a little afdruk medicine on the *screen*, flatten the afdruk treatment utilizing a rake, and ensure the afdruk medicine coats the *screen* thinly and evenly. Heat the design with a lamp. Attach the screen-printing film to the part of the *screen* that has been coated with afdruk medicine using tape. Put the *screen* on the printing table, point it at the lamp and put the load on the *screen*, turn on the light and wait for 15 minutes. Then, remove the screen-printing film.

   The design results look as if they are burning and attached to the *screen*. Clean the *screen* by spraying cold water using a water spray until the afdruk medicine peels off the design part, and over time, the shape of the design will be seen more clearly and dry the *screen*. The blocking process will begin. Put the invitation on the screen-printing table, then place the *screen* in the area you want to screen print. Adjust the design position to the position of the invitation part to be printed. Then, attach the tape to the *screen* that does not have a screen-printing film. On the screen's surface, pour the screen-printing ink slowly in a horizontal direction and flatten it one way down using a rakel until the ink coats the *screen* evenly. After that, keep the ink up and down using a slightly pressed Rakel until the ink can be pushed onto the surface of the invitation evenly. Lift *the screen* slowly, and the screen-printing process has been completed. The screen-printing process has been completed and only needs to wait until the screen printing ink dries so that the screen-printing results are neater.

5.2 Stages of Analysis with the Six Sigma Method

There are four stages of Six Sigma in this study

1. Define

The defined stage is the stage of categorizing product defect data to improve product quality. Identifying CTQ (Critical to Quality) is done by interviewing business owners.
There are three types of disability, which can be seen in Table 3.

Table 3 CTQ (*Critical to Quality*) on the invitation production process

CTQ	Types of Damage	Damage Description
CTQ-1	Untidy invitation folds	The position of the fold of the invitation is not precise with the existing reference line on the invitation paper, which results in the invitation being tilted.
CTQ-2	The screen printing results are not neat	The spilled ink print on the invitation letter makes the printed writing blurred and shaded, so the paper is not visible.
CTQ-3	Blurred printed ink	The lack of thick print on the invitation stamp causes the writing to be blurred and striped so that the paper is not visible.

Data on the type of disability and the number of defects in the production of invited products in CV XYZ Month Januari-June 2022 can be seen in Figure 1.

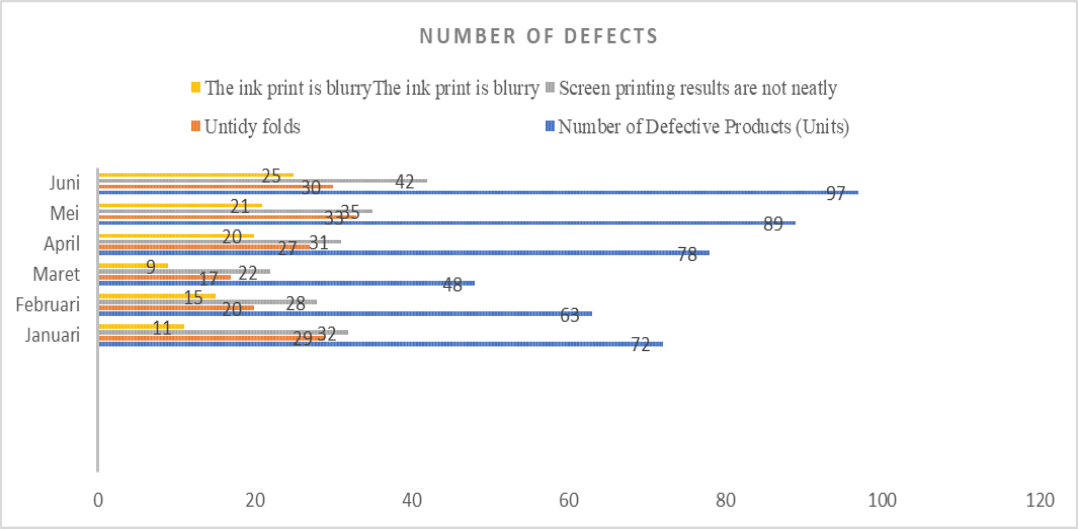

Figure 1. Data On the Type of Disability and The Number of Defects

Based on Figure 1, the highest type of product defect is found in the screen-printing process. Where the results of the ink print on the invitation letter make the printed writing blurred and shaded so that the paper is not visible.

2. Measure

2.1 Process Stability Analysis

a. Control Map Analysis (P-Chart)

This control map (P-Chart) is created to determine whether the defective product is still within the required limits using attribute data, namely the number of production and faulty products. A recapitulation of the permit with Upper Control Limit (UCL), Control Limit (CL), and Lower Control Limit (LCL) is presented in Table 4.

Table 4 Control Limit Results and Proportions control Map P

Moon	Number of Productions /Month (Unit)	Number of Defective Products (Units)	P	CL	UCL	LCL
January	3,300	72	0.022	0.030	0.022	0.014
February	3,200	63	0.020	0.030	0.022	0.014
March	2,800	48	0.017	0.030	0.022	0.014
April	3,400	78	0.023	0.029	0.022	0.014
May	3,700	89	0.024	0.029	0.022	0.015
June	4,000	97	0.024	0.029	0.022	0.015

From the results of the calculation of the control limit in Table 4, a p *chart* can then be made, which can be seen in Figure 2:

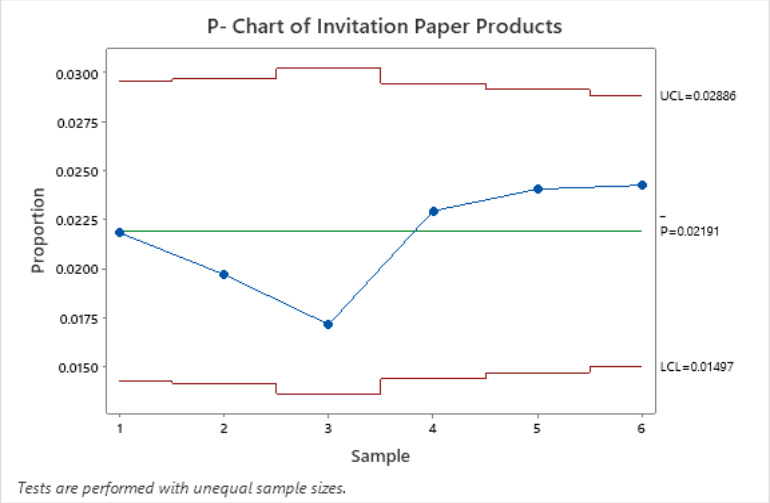

Figure 2 P Chart on the Invitation Letter Production Process

CV XYZ is stable but has a reasonably high disability rate of 2.16%. Based on Figure 2, it can be seen that the data obtained are entirely within the control limit. This shows quality control in MSMEs. It also states that quality control in CV XYZ requires improvements to reduce the product's defects to zero.

b. Measuring Six Sigma capability levels and Defects Per Million Opportunities (DPMO)
This measurement of the sigma level and DPMO value is carried out to analyze the sigma value level of the invitation letter production process and measure the number of prose ability.
Converting the DPMO calculation results with the Six Sigma table to get the sigma value can be seen in Table 5.
Table 5 Calculation of DPMO and Sigma Values.

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Moon	**Number of Productions/Month (Units)**	**Number of Products Defective (Unit)**	**CTQ**	**DPMO**	**Value *Sigma***
January	3,300	72	3	7,272.727	3,94
February	3,200	63	3	6,562.500	3,98
March	2,800	48	3	5,714.286	4,03
April	3,400	78	3	7,647.059	3,93
May	3,700	89	3	8,018.018	3,91
June	4,000	97	3	8,083.333	3,91
Average	3,400	74.5		7,216.321	3,95

Barat Advertising is not handled because more and more products fail in the production process. The calculation results in Table 5 show that the CV XYZ production process has an average sigma value of 3.95 with possible damage of 7,216,321 products for every one million productions. This is certainly a big loss for CV XYZ.

3. Analyze

1. Diagram Pareto

A Pareto diagram of the defects of the invitation letter production process can be seen in Figure 3. This Pareto diagram sorts by the degree of a proportion of the most significant damage to the smallest injury. This Pareto diagram will help to focus on the problem of product damage that occurs more often for repairs to be carried out.

There are three causes of disability: untidy screen printing, untidy folds, and blurred print results. The leading cause of disability is messy screen-printing results, with a percentage of total disability of 43%. Other reasons, namely untidy folds with a rate of 34% and blurred prints with a ratio of 23%.

2. Fault Tree Analysis (FTA)

a. The ink printouts on the invitation blank make the printed writing blurred and shaded, so the paper is not visible. Figure 3 shows fault tree analysis for untidy screen-printing defects.

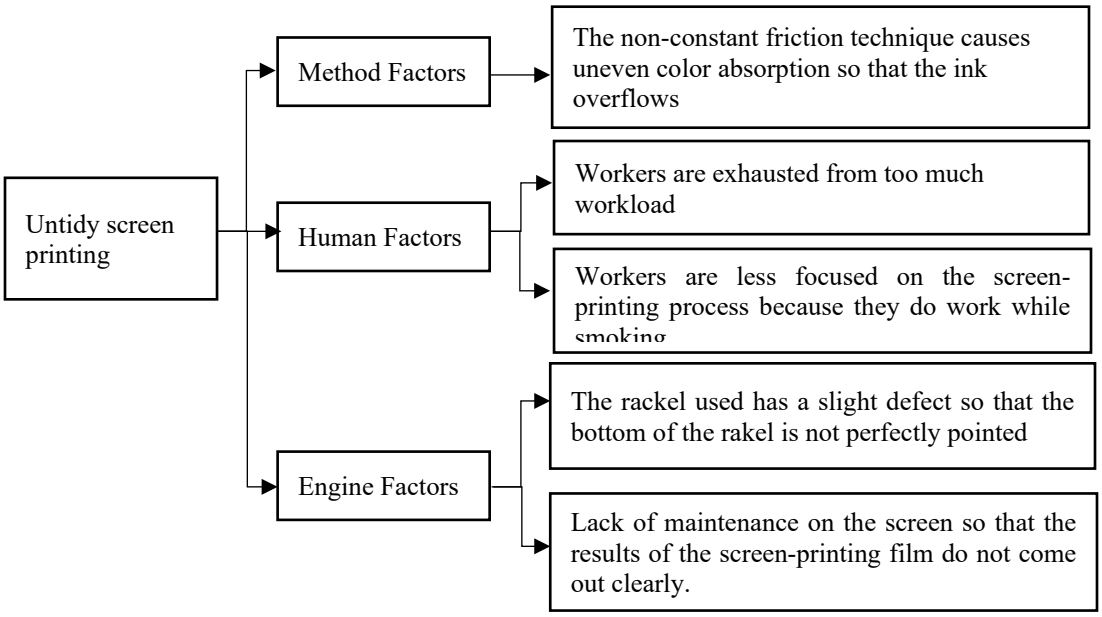

Figure 3 Fault Tree Analysis ff Screen printing Defects Is Untidy.

b. Untidy folds

The result of the invitation fold is not precise, with the reference line on the invitation paper blank resulting in the invitation fold being tilted. Figure 4 shows fault tree defects and untidy folds.

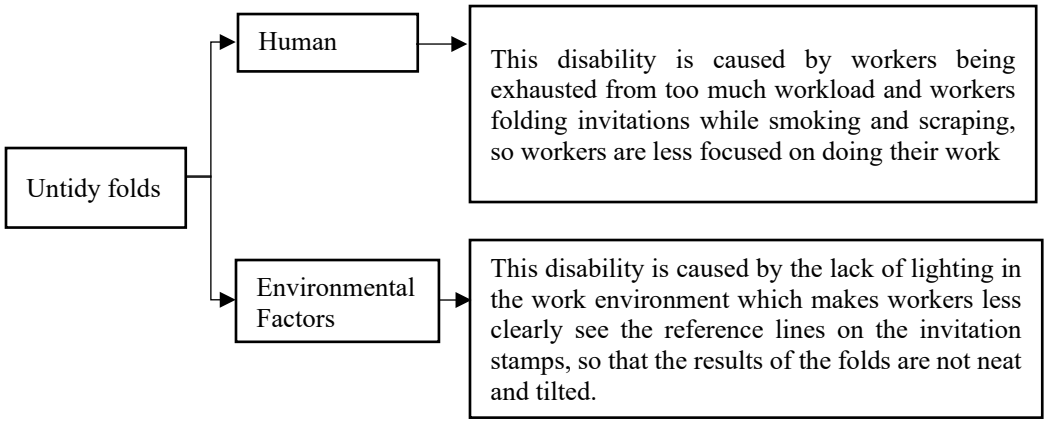

Figure 4 Fault Tree Defect Untidy Folds.

c. Blur Print Results

In this type of disability, four factors affect it: the method, human, material, and machine factors. Figure 5 shows fault tree defects resulting from print blur.

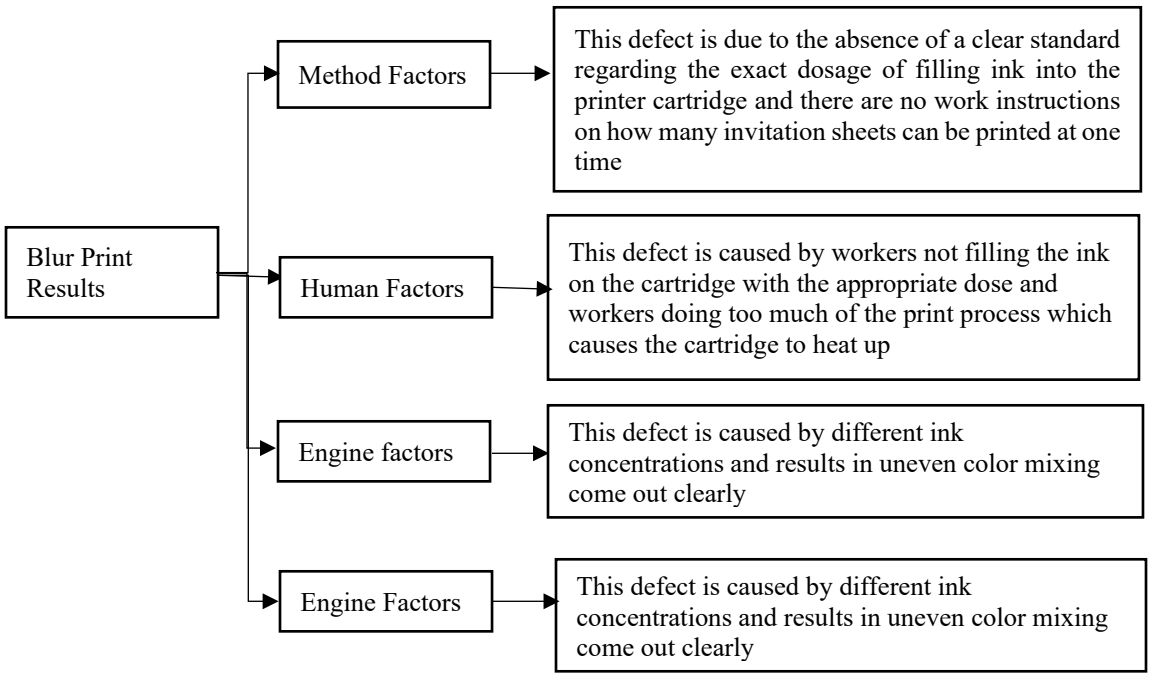

Figure 5 Fault Tree Defect Prin blur Results

4. Improve

Recommendations for proposed improvements from three types of defects that occur in invitation products are carried out using the 5W +1H method to determine the improvements that can be made to defects that arise in CV XYZ. The following is a 5W+1H analysis of three types of defects in invitation products. (Tables 6- 8)

Table 6 for 5W+1H Improvement of Untidy Screenprinting Defects

Factor	What	Where	When	Why	Who	How
Human	Lack of Focus	Screen printing process	When workers make a swipe gesture	Smoking while doing work	Bag workers. production	Applying rules if you're doing work shouldn't be while doing anything else, like smoke.
Method	The friction technique is not constant	Screen swiping *process*	At the moment when Rakel shifts screen printing ink	Workers do not lift non-existent constant	Bag workers. production	Set the swipe technique one time towards the bottom and two times towards the top.
	The ink is too watery	Screen printing ink ran mixing	During the mixing process n screen printing ink	Thinner gave too much		The mixing process of screenprinting ink and thinner is carried out in a ratio

Material		process	with Thinner		Bag workers. worker	of 1: 1
	The afdruk process is less than perfect	The process of mixing ran the drug afdruk	At the time of the mixing process n sensitizers and emulsions	The dose of the sensitizer and emulsion does not fit		The process of mixing afdruk drugs, that is, sensitizers and emulsions, is carried out in a ratio of 1: 1

Table 7 for 5W+1H Repair of Untidy Fold Defects

Factor	What	Where	When	Why	Who	How
Human	Lack of Focus	The process of folding invitation blank	At the time, the worker folds the invitation blank into two parts	Smoking and chatting too much while doing work	Bag workers. Production and bag. Designer	Applying rules if you are doing work should not be while doing other things, such as smoking and focusing too much on chatting
Milieu	Lack of lighting	In the work environment	At the time, the worker folds the invitation blank into two parts	The work environment is not bright enough so that the reference line on the invitation letter is not visible clear	Bag workers. Production and bag. Designer	Checking the lights and replacing the lights in the work environment

Table 8 for 5W+1H Rectification of Blurred Print Defects

Factor	What	Where	When	Why	Who	How
Human	Too many print invitations	Invitation print process	When workers carry out the print process	*Cartridge* getting hot	Bag workers. Designer	Provide work instructions on how many invitation sheets should be printed in one time
	The volume of ink is not filled according to the dose	Ink refilling process	At the time, the worker refills the ink on *Cartridge*	Does not fill the ink with the right dose		Provides clear standards and instructions on ink fill dosing

Machine	Cartridge hot	Invitation print process	When workers carry out the print process	*Cartridge* fatigue due to too many print invitations at one time	Bag workers. Designer	It gives a pause every10 minute after printing the invitation for as many as 100 sheets
	The ink has not been mixed well			The volume of ink that is still too concentrated and the volume of ink which is lacking		Filling the ink on the *cartridge* after printing the invitation as much as 200 sheets
Material	Ink concentration	Invitation print process	When workers carry out the print process	Too many print invitations	Bag workers. Designer	Refilling the ink on the *cartridge* with the right dose

6. Conclusion

The types of *defects* that most often occur during the invitation creation process are as follows:
Untidy Invitation Folds: The position of the invitation folds is not precise with the existing reference lines on the invitation paper stamps, resulting in the invitation being tilted.

Untidy Screen printing Results: The spilled ink print on the invitation letter makes the printed writing blurred and shaded, so the paper is not visible.

Blurred Print Ink: The lack of thickness of the print on the invitation letter causes the writing to become blurred and striped so that the report is not visible.

The level of process capability based on DPMO and Sigma values shows that the average sigma value is 3.95, with possible damage of 7,612,321 products for every one million productions, where the sigma level achieved is still far from the desired target of 6 sigma and 3.4 DPMO.

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