Productivity Improvement in Textile Industry using Lean Manufacturing Practices of 5S & Single Minute Die Exchange (SMED)

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Abstract

This research was conducted in a leading textile industry of Pakistan. The focus of the research was the reduction of overall changeover time at Flatbed Printing machine. The machine was facing longer changeover times due to which the overall equipment efficiencies and productivity was affected. Therefore, the aim of this study was to reduce changeover time to improve productivity by applying Lean Manufacturing (LM) technique of Single minute exchange of dies (SMED). The changeover activities were recorded and analyzed. The time & motion study was conducted and internal & external activities were identified. Few potential internal activities converted to external. The remaining internal activities were of optimized by suggesting optimal method. The standardization is suggested for proposed solutions to the bottleneck activities so that the same problem will not occur in the future. It has been observed that the SMED implementation along with 5S leads to decrease in changeover times and waste elimination. The changeover time was reduced from 142 minutes to 117 minutes which in turn increased the overall productivity of flatbed printing machine. It can be further minimized by proper training of concerned workers and creating awareness among them about LEAN environment.

Keywords:
Single Minute Die Exchange (SMED); lean manufacturing; textile; changeover; 5S.

1. Introduction

In the existing age the crucial element of competition between enterprises is differentiation. This distinction can be achieved in a number of means, either through innovation at the level of ingenious items or with technology in production procedures (Godina et al., 2018). Every industry has a growing demand to boost top quality, output as well as voice of the customer complete satisfaction (Karam et al., 2018). In order to remain on the market and also come to be competitive, the functioning techniques exercised should reliable and efficient (Sousa et al., 2018). Wild-goose chase in the packaging analysis procedure can trigger hold-ups in the manufacturing procedure. This problem affects the speed in meeting consumer demand. Calculation of lead time evaluation of packaging is very important to determine to ensure that the release of packaging for manufacturing can be on time (Haifa & Permatasari, 2020). The significance of the moment invested in manufacturing transitions has actually been popular for a very long time (Antunes et al., 2016). SMED is the tool of lean manufacturing which is utilized to reduce the transition times of makers. The main emphasis of SMED is the makeover of internal activities of the arrangement stage to external tasks. In manufacturing, an internal task is any kind of operation that can just be done if the machine is closed down (for instance, connecting or eliminating the passes away). An external activity can be performed when the machine is running (Antunes et al., 2016). SMED is a collection of methods belonging to Lean producing that goal to lower the arrangement time of a device. When correctly applied, it allows equipments to take less time to attach, providing more flexibility to the line (Godina et al., 2018). Enhanced productivity can take place if there is a downsizing procedure that can determine earlier waste and also quality problems that are likely to take place in the future (Kusrini & Parmasari, 2020). Among the time-waste according to the lean production principle is the installment of

developing dies to a press. Numerous methods are being established to solve this problem, such as a Solitary Min Exchange Die System (SMED) which thinks about just the technique to lessen the setup of creating passes away to practically 25-30 percent, but it does not consider the reduction of the forming process or series (Nakeenopakun & Aue-U-lan, 2020). The effective and also reliable transition process is an important element that supports the production control procedure for the majority of the manufacturing production line. It is much more crucial if the demand is very complex (e.g., fluctuate, ranges of items specification). Therefore, it is able to reduce the production lead times and assist in attaining better requirements (Ahmad & Soberi, 2018).Michels (2007) found that SMED application can improve as well as minimize the moment for modification over efficiently to reduce straight labor as mentioned by (Herlambang, 2020). 5S is a Japanese method of organizing the work area, in a clean, efficient and also secure fashion, in order to accomplish a productive work environment. The 5S is a starting factor for any type of organization that wants to be identified as a responsible producer, worthwhile of top quality status (Veres et al., 2018). The 5S (kind, set, shine, systematize and endure) lean tool has been known to enhance system efficiency (Omogbai & Salonitis, 2017). Application of 5S belongs to a continual enhancement (Kaizen), aims to boost high quality and work systems within a company (Sari et al., 2017). Objective of the present study was to maximize the transition time as well as lessen the things 'retrieval time from the shade kitchen by the use SMED and also 5S techniques in the printing vicinity of ABC Textile Company, Karachi.

1.1 Problem Statement

In textile industry huge time is wasted during changeover time of printing machines due to unnecessary activities (material flow and worker movement) that decreases production rate of the machines. The problem identified at flatbed buser printing machine was “excessive changeover time and unavailability of pre-requisites which lead to wastage of time”. Setup and changeover times were higher than normal due to several issues that included manual transportation of drums and holders which cause the greater wastage of time. At the same time, color much of the time was used to be wasted on having the color dyes from the store because of un-organized storage of color drums. This was the reason to conduct the present research to optimize the changeover time and reduce the time to retrieve the color drums from the color kitchen.

1.2 Research Objectives

The main aim of the present research was to optimize changeover time of (BFPM). Mentioned aim was achieved by the below mentioned objectives.

1. To analyze the setup operations and identify the targets for improvement
2. To eliminate non-value-added activities and simplify changeover activities.
3. To reduce idle time of equipment and labor in order to optimize the resource utilization.

2. Literature Review

Some of the pertinent investigation is presented on the subjects i.e. SMED and 5S of recent years. Haifa as well as Permatasari (2020) carried out a research experimentally by using empirical information on testing specifications of packaging analysis from 1 set number on 32 barrel. Based on data from monitoring made on the primary packaging evaluation of the flexy bag, there are 23 tasks consisting of 18 internal activities and also 5 tasks that can be converted to external. The results of applying the SMED method in this research study can decrease set-up time by 58.06% or 13.18 hrs(Haifa & Permatasari, 2020).Karam et al (2018) exhibited the accomplished outcomes after implementing SMED devices at a certain production line in the Romanian pharmaceutical sector. Finishing Changeovers between products on a certain product packaging equipment making use of Solitary Minute Exchange of Passes Away (SMED) technique provides the opportunity to shorten the equipment downtime, enhancing the final output. Implementing Lean Production philosophy, significant change over time at the bottleneck procedure decreased by 30% in year. Together with the financial benefits from the SMED application, process high quality, standardization and also synergy have actually been boosted (Karam et al., 2018). Sousa et alia (2018) used SMED approach in such a way to reduce the downtime brought on by device changes, and also a decrease of 43% in total changeover time was acquired (Sousa et al., 2018). Hidayatet alia (2020) improved the maker established time using SMED method. The tasks were determined which were carried out in the maker and also they were set up to be divided into 2 tasks particularly internal activities as well as external activities. Prior to the enhancement the established time needed by the business was 5,938 minutes/month, after using the SMED method the set up time became 3,008 minutes/month (Hidayat et al., 2020). Kusrini and Parmasari (2020) aimed to boost system incurable container (UTC) performance making use of the idea of lean supply chain management by assessing utilizing worth stream mapping (VSM) and enhancement with Single Min Exchange of Dies (SMED) as well as 5S (Seiri, Seiton,

Seiso, Seiketsu, Shitsuke). Based on result of VSM, it is acquired the highest possible waste in unneeded activity (18,574%) and also transportation of papers (18.154%) with value added tasks of 60.81% and the percentage of non-value-added tasks of 39.19%. Improvements making use of SMED approach and 5S caused boosted effectiveness from 60.81% to 70.20% (Kusrini & Parmasari, 2020).Bimantoro et al (2020) conducted their research by using the SMED technique can be lower the configuration aspects on the internet equipment from 38 task elements to 32 arrangement components, while on the TSK machine minimizing from 51 task components to 34 arrangement elemens. The 5S concept itself can decreasing configuration time on a WEB machine to 31.47% and TSK machine to 49.31% (Bimantoro et al., 2020).Mulyana and also Hasibuan (2017) intended to determine variables causing high changeover time model on punching equipment and make improvement with SMED method (single minute exchange of passes away). Execution of SMED technique is done by optimizing external task on telecommunication panel production with sychronisation of activity. Observation carried out for one month making use of research study time prior to as well as after implementation of SMED. Execution of the SMED technique is done by transforming 15 internal tasks into 5 internal tasks and crafted the scale device to reduce engine downtime. Enhancement acquired is decreased downtime maker punching time from 44.90 hours to 10.96 hours or a decline configuration time of 75.59% (Mulyana & Hasibuan, 2017).Nakeenopakun as well as Aue-u-lan (2020) used the SMED strategy and validated with different wheel versions; outcomes showed that virtually 60 percent of the forming dies can be decreased (Nakeenopakun & Aue-U-lan, 2020). Ahmad and Soberi (2018) shared an actual industry experience for a renovation project of the changeover process through a SMED technique and also various other procedure enhancement application tools. The project focuses on the changeover tasks for one of the innovative composite manufacturing procedures, called cutting process that entails 5-axis CNC equipment procedure. The cause and effect and also five whys evaluation techniques and also some steps of conventional SMED are applied in this improvement job. 4 common strategies and priorities series are introduced for an extension action of standard SMED. The theoretical decision version was then proposed to present the organized improvement procedure performed in this project. 4 specific services from the selected techniques are then advised to be carried out. The application results showed that the complete changeover time is lowered to 44% and internal kind tasks time is decreased to 48% (Ahmad & Soberi, 2018).Herlambang (2020) aimed to reveal the results that have actually been attained after the implementation of SMED in the marking department of an electronic component company. Actions to Specify, Measure, Enhance, Control, as well as Enhance are approaches to attain this investigation's purposes. The Work-Study method is made use of to perform activity disintegration to help with the repair service procedure. Executing SMED in electronics business can minimize changeover time by as much as 41% (Herlambang, 2020).Sabadka et al (2017) explained concepts, benefits, procedures as well as practical application of SMED. Theoretical bases are validated in an useful part that describes the analysis and also design optimization of non-productive time at changeover honing device in a chosen shaft producing company. The outcome is the structural style of global combinations and an evaluation of efficiency because of optimization of operations of time honing equipment shafts. The results showed substantial reduction in delay developing out of machine setting time, batch-setting time and also presentation hold-up (Sabadka et al., 2017).Veres et alia (2018) suggested the positive connection in between 5S Level as well as Productivity in an automotive cable television production plant, and the goals defined at the start has been satisfied. This suggests that implementing as well as maintaining 5S approach and also requirements in the firm brings about enhanced performances (Veres et al., 2018).Omogbai and Salonitis (2017) created system characteristics model for a production case study as well as simulated to develop the effect of sorting activity on manufacturing throughput. The purpose was to examine, in advance, the system performance end results when 5S techniques are enhanced. The simulation results were the stimulus for real life renovations in the system since the simulation results were able to imitate the real-life end results. While the simulation results urge additional renovations to be executed, the model created in the present paper is replicable in other circumstances as the variables made use of in the design are generic as well as common to the majority of kinds of producing systems, especially those new to lean practices. The dynamic analyses of 5S lean practices is not usual. The research study additionally reveals some intriguing partnerships in between 5S as well as other lean techniques as well as in between 5S and system performance (Omogbai & Salonitis, 2017). Ashraf et al (2017) explored the application of 5S approach to a real world manufacturing situation at a food & drink market. Originally, the whole system was examined as well as this revealed a great deal of incongruities in different locations. Enhancement proposals were made based on 5S and also were executed over the course of following couple of months. From the proposed renovation proposal, great deals of advantages such as space saving, money saving, increasing productivity, lowering denial of parts and a lot more were attained (Ashraf et al., 2017). Sari et al (2017) discussed 5S implementation in Job System Style and Ergonomic Laboratory, Department of Industrial Engineering, Islamic University of Indonesia. There are some troubles connected to devices setups for activity including trainees such as files which is accumulated over the previous year practicum, as well as the activity of

waste in the form of time due to the placement of items that do not fit. As a result, this research aims to apply the 5S approach in DSK & E research laboratory to help with the work procedures as well as decrease waste. The job is done by lab administration utilizing 5S methods in action to continual renovation (Kaizen). In addition, some method as well as suggestions are promoted to impose 5S system within the lab. As a result, the cleanliness and also sanitation can be attained that lead to the great performance of research laboratory individuals. Rating analysis prior to applying 5S DSKE laboratory is at 64 (2.56) while the score after application is 32 (1.28) as well as reveals an enhancement of 50%. This has implications for better use in the laboratory location, conserve time when searching for tools and products because of its place and also great visual control, in addition to boosting the society and spirit of '5S' on personnel relating to better workplace (Sari et al., 2017).

3. Research Methodology

3.1 Data Collection

At the very first changeover procedure of the machine was observed and its activities were collected. Multiple time and motion study sheets were made. Simultaneously, times for each changeover activity and movement of each worker on that machine were recorded by the use of time study sheets, stopwatch and camcorder. The average value of collected observationswere used to represent time requirement for each changeover activity. Based on the collected data and observation, each changeover activity was classified into internal and external processes. Moreover, data of items present in the color kitchen was obtained from the store. After the implementation of SMED and 5S, the pictures of improved systems were captured.

3.2 Data Analysis

The color kitchen inventory needed to be rearranged orderly in order to save the time wasted ignorantly. For that purpose, HML and FSN analyses were carried out on the past three months consumption data of the kitchen to arrange the orders with respect to the trend in their demands.After thorough analysis, the value added, and non-value-added activities were identified and analyzed which led this research to the identification and implementation of SMED technique. Collected data was then put intoMicrosoft Excel for analysis and calculations. For graphical representation, bar charts, line charts were used. Moreover, north-west corner matrix was also used. In addition, videos, time study sheets were used to facilitate the analysis.

3.2.1 Case Study

3.2.1.1 Overview of Company`s Process

The production of a textile basically starts from the collection of fiber then spinning it which is followed by weaving and then the fabric is sent to the pre-treatment. It is followed by bleaching, dyeing printing and folding. Present research paper is focused on flatbed section of the printing department.

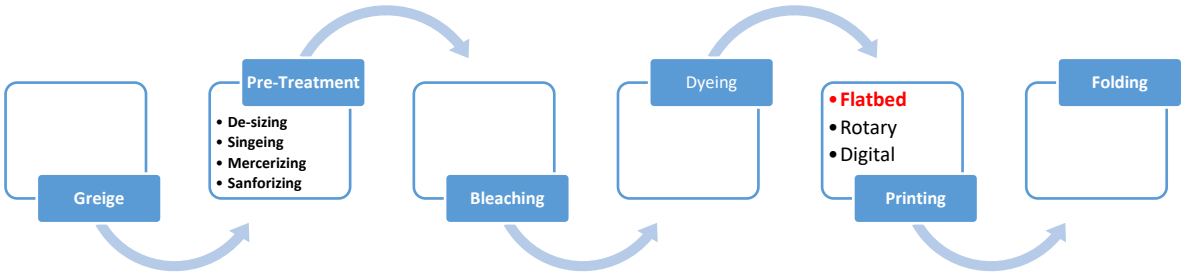

Figure 1. Process flow of production

3.2.1.2 Buser Flatbed Printing Machine

BFPM is a conventional printing machine. The printing mechanism consists of embossed screens which stamp the fabric passing beneath them by using either reactive or pigment dyes depending on the nature and complexity of designs. Sequentially the engraved screens are placed on the machine then the holders are fitted, where the purpose of holder is to carry the dye and spread it out onto the screen evenly when the machine is running.After placing the holders the brackets of screens are also adjusted in accordance to the warp and weft lengths of the fabric. After all

the machine setup is completed, the machine starts and fabric starts passing under the screens and get stamped under each of them.

The primary objective of this project was to reduce changeover time of the BFPM by eliminating the unnecessary activities and rearranging the order of necessary activities performed. We started by observing the invaluable time being not utilized at the best which was causing excessive time wastage and affecting the overall equipment efficiency. The major problematic activities were either due to manual transportation of items to and from the machine or the potentially external activities being performed as internal activities. And the unorganized color kitchen was also playing its part well in the time wastage because it used to take longer time for the searching of required dyes on time of need.The activities that take place when the machine has completely stopped were termed as external activities and those which were supposed to be performed at the running time were called as internet activities. The process sequence at the flatbed is presented below;

Receiving Order: First of all an order is received, from the planning department, which is to be processed at BFPM
Preparing the Color Recipe: Then according to the design mentioned in order, the color kitchen labors prepare a recipe of colors that are to be used in the order and then the recipe is printed on the piece of fabric to make sure it's a perfect mix.
Receiving Fabric: After the recipe is finalized, the receipt of fabric is ensured to carry out the production.
Placing Screens: Once the recipe is made and the fabric is received, the formal production process starts with installing the screens on machine as per the required order design.
Placing Holders: After installing the screens, the holders are placed on the machine which acts as a dye conveyor on the screen during production.
Placing Drums: The dye drums are then placed alongside their relevant design screens on the machine.

Bracket Adjustment: After all the accessories are placed and setup is completed the brackets of screens are adjusted according to the warp and weft length of the fabric.

4. Results

Results are divided in four section i.e. implementation of SMED, research area for 5S implementation, implementation of 5S and comparison of the current and suggested methods.

4.1 Implementation of SMED

There are five steps in the way to implementation of SMED. All the steps are described in detail under separate headings.

4.1.1 Step 1: Identify the Pilot Area

The potential area for conducting the study was considered to be the flatbed printing machine during the changeover and setup time, which was taking excessive time to adding to the wastage in the process. Research area is described in detail in heading 7.2.1.

4.1.2 Step 2: Identify the Elements

After the observation of the complete process and identifying the problematic issues visually, researchers recorded the time of each activity individual by using stopwatches. They collected the readings for 3 different changeovers differing on the basis of number of screens used ranging from 3 screens to 8 screens per design. In order to generalize the situation, an average of 5 screens per design was set up for the analysis (see table 1).

Table 1. Activities at Flatbed Printing Machine

Sr #	Parent Activities	Activities	3 Screens (min)	7 Screens (min)	8 Screens (min)	5 Screens (min)
1	Placing holders	Removing holders	6.80	12.24	14.00	9.00
2	Placing screens	Removing screens	6.50	13.30	14.70	11.00
3	Placing drums	Removing drums	6.85	8.40	10.30	6.00
4	Placing screens	Screen washing	6.50	9.35	10.50	7.00
5	Placing holders	Holder washing	9.75	18.00	12.30	16.00
6	Placing screens	Screen placement	3.70	8.40	9.50	6.00
7	Placing screens	Screen fitting	7.30	12.50	15.20	10.00
8	Placing drums	Drum placement	8.00	12.80	13.50	9.00
9	Placing holders	Holder placement	7.40	11.90	7.00	4.00
10	Placing holders	Holder fitting	5.60	8.15	9.00	6.00

11	Placing screens	Screen adjustment	51.00	58.00	61.00	58.00
Total			**119.4**	**173.04**	**177**	**142**

The data for the changeover times was collected by using stopwatches and time study charts to record the individual times taken by each activity. At the same time, another method was also used to conduct the time study of different workers on the same task. These observations were recorded in order to analyze and compare the performance of workers on the same task. This could help in setting the standard times for each process. Its primary purposewas to break down the activities in smallest movements the workers perform while doing their work. Most importantly, it was also used to determine the absolute nature of the activities i.e. internal or external.

Table 2. Multi-activity Sheet for Two Workers Working Simultaneously

Tasks	Worker 1	Worker 2
Removing Holder 1	0:00:48	0:00:35
Removing Holder 3	0:00:54	0:00:41
Removing Holder 5	0:00:52	0:00:38
Removing Holder 7	0:00:44	0:00:41
Taking Screen Back to Washing 2	0:00:33	0:00:43
Back to Machine	0:00:30	0:00:28
Taking Screen Back to Washing 4	0:00:38	0:00:55
Back to Machine	0:00:23	0:00:52
Taking Screen Back to Washing 6	0:00:20	0:00:35
Back to Machine	0:00:24	0:00:19
Taking Screen Back to Washing 8	0:00:22	0:00:45
Washing Area	0:00:46	0:01:55
Screen Washing	0:00:21	0:00:38
Placing Screen to Side	0:00:23	0:00:15
Moving Screen Outside	0:00:36	0:00:13
Back to Washing Area	0:00:28	0:00:26

Whereas the mainly focused activities were; drum placement, holders removal, screen removal, drums removal, holders placement. The selected activities had the capacity to be modified/improved. Some of the concurrent activities noted worker wise are mentioned in the table 2.

4.1.3 Step 3: Separate External Elements

After analyzing the changeover times and the recorded data, it was necessary to determine the status of the each activity. As mentioned earlier, there were two types of activities i.e. internal (activities which are performed when production is done) and external (activities which are performed while the production is running). The internal activities include placing drums for next order, removing holders, removing screens, removing drums, screen placement, screen fitting, holders placement, holders fitting, screen adjustment, holders washing and screens washing.

4.1.4 Step 4: Convert Internal Elements into External

After the identifying the nature of all the activities i.e. either internal or external, then the next stage was to convert the internal activities into external. After the identification of nature of activities, it is found that some of the activities could be converted into external setup by just rearranging the process and that could help in reducing the overall changeover times to a greater extent. Modification fashion of the activities is presented below.

Placing Drums on Flatbed: This activity means to place the new drums of dyes for the next order which was previously performed as internal. This could be done during the last minutes of the current order to change its nature to external activity. It was well known which order is to be produced, its dyes are already mixed up in the color kitchen. All it takes is to transport them to the needed places before the current order ends.

Removing Screens: This is the activity in which the screens which were used in the current order are removed from the machine. This was completely internal, as the screens were removed after the completion of production. For that a mathematical equation was used.

$$n^{\circ} = n - 1 \tag{1}$$

Where,

n^{o}= Screens to be removed
n = Current screen from where the fabric passing

This equation means that every screen must be removed immediately after the fabric passes through it for the last time. Whereas the removal of last screen remain internal.

Removing Holders: This activity was also previously internal in nature and this can be converted to external by the use of (1). In this way, by converting the major part of an activity to external can save a lot of non-value added time.

4.1.5 Step 5: Streamline

After the in-depth observation and analysis for elimination of the non-value added time changeover time, some steps were suggested for the flatbed machine to streamline the process which could play their part in a quicker changeover. Suggestions included; all the screens except the last one on the machine must be removed before the production completely stops hence making it an external activity.Therefore, removal of last screen remains as an internal activity, which also should be done immediately after the machine stops.

4.2 Research Area for 5S Implementation

Color kitchen was selected for 5S implementation because of its closer relationship with BFPM. The color drums were supposed to be transported from color kitchen to the BFPM and due to un-organized storage, it used to take longer times to take and transport the color drums to BFPM. In this regard, it was necessary to organize the color drums` storage in order to minimize the time of retrieval of color drums.

4.2.1 Color Kitchen Inventory

The data required for organizing the inventory at color kitchen was provided by Central Store. And the past three months data of November 2018, October 2018 and January 2019 was recorded and kept for carrying out analyses in order to optimize and organize the inventory for quicker and efficient operation at color kitchen which eventually aids in the reduced changeover times of BFPM. The data consisted of 63 different dyes (including pigment and reactive) that were used during the stated time with their opening and closing balances at the color kitchen. The raw data provided by the store was then converted into the valuable information i.e. average stay and the consumption rates of items stocked in the kitchen. Moreover, the explanation of terms used are mentioned in the table 3.

Table 3. Descriptions of Terms used in the color kitchen

Terms	Explanation
Pigments	The type of dye which is a water insoluble coloring material used in textile printing and dyeing.
Opening	The opening balance of the relative pigments in the color kitchen, at the start of the day. These values are given in lbs.
Receiving	The quantity of the pigment received from the main store upon placing an order.
Issuing	The quantity of pigment issued for making the recipes. Or it can also be stated as the amount of pigment used in the whole day long production.
Closing	The quantity of remaining pigments in the inventory is noted at the end of each day.

The raw data is collected from the store and the daily opening, receiving, issuing and closing balances of the pigments are calculated and tabulated in the proper manner.

4.3 Implementation of 5S

Implementation procedure of 5S followed three steps i.e. analyzing the problem, techniques and standardization. Each of the step was presented in detail in separate heading.

4.3.1 Analyzing the Problem

The implementation of 5S was inevitable in the color kitchen because of the unorganized arrangement of drums and ineffective utilization of the workspace. Due to a smaller workplace and improper arrangement of items in it, it was causing some major issues i.e.

- Excessive time wasted to reach the required drum when it is needed, due to congestion of the workplace.
- Wastage of dyes, itself sometimes when the worker tries to hurry and jump over the drums to get to the required one.
- Wastage of dyes (in rare cases) when the worker mixes wrong dye in the recipe, because of improper labelling on the drums.

Keeping these issues aside, the improper arrangement of drums was also causing the delayed transportation of the dyes to the machine which eventually was adding to increase the wastage of time in changeovers. Thus it was the

highest need to implement 5s in the color kitchen to overcome all the issues as well as to aid in the possibility of quicker changeovers.

4.3.2 Techniques

There were three techniques used for the implementation of 5S i.e. FNS analysis, HML analysis and FNS-HML matrix as explained in the below given headings.

4.3.2.1 FNS Analysis

The FNS Analysis was used to classify the provided data on the nature of their average stay period in the inventory and their consumption rates. The criteria can be seen in the table 4. By the help of the mathematical formulae, the needed information was derived out of the raw data provided by the store. And then the criterion were set to classify items as fast moving, normal moving and slow moving items.

Table 4. Classification of fast, slow and normally moving items

Average Stay	**Classification**
0-70%	S
70-90%	N
90-100%	F
Consumption Rate	**Classification**
0-70%	F
70-90%	N
90-100%	S

Then on the basis of these two characteristics, a combined criterion was formulated to classify the items into three categories as presented in the table 5.

Table 5. Combining criterion for derivative values

Consumption Rate	**Average Stay**	**Combined**
F	F	F
F	N	F
F	S	N
N	F	N
N	N	N
N	S	S
S	F	N
S	N	S
S	S	S

All of the 63 items were then classified into the fast, normal and slow moving categories based on the stated criterion and tabulated in the proper manner. All the items/pigments and the complete FNS analysis on all the 63 items used on the FBPM during past three months are tabulated in the proper manner.

4.3.2.2 HML Analysis

HML analysis is a qualitative technique used to determine the criticality of items. For example, which of the items are highly critical and should be kept in stock all the time for smoother process flow;medium critical items were those which were not used in everyday use but must be kept in low quantities in the stock; low critical items that are used in the production seldom and can be ordered if seems to be required just upon time but no need of keeping them in stock regularly.

To conduct HML analysis of the items, the supervisors were contacted and interviewed to determine the criticality of items. The interviewed personnel were given a ranking scale for their convenience to rate the items on their nature of criticality. They were asked some questions i.e. (1) which colors are the most important in daily usage? (2) How much quantity is always kept at a minimum to be safe from any kind of inconvenience? (3) Which colors are used in the production rarely? (4) How long do the rarely used items take to be receipt when ordered?

4.3.2.3 FNS-HML Matrix

Then the data gathered from these two stated analyses were merged in a matrix in table 6 for accuracy and five categories of items were made on the basis of their results.

Table 6. FNS-HML Matrix criterion

Criterion	Categories
High – Fast	1
High – Normal	2
Medium – Fast	2
High – Slow	3
Medium – Normal	3
Low – Fast	3
Medium – Slow	4
Low – Normal	4
Low – Slow	5

The matrix itself made it clear for the classification of items and dealing them accordingly to their average stays, consumption rates and criticalities which are mentioned in table 7.

Table 7. FSN-HML Matrix

	H	*M*	*L*
F	**1**	**2**	**3**
N	**2**	**3**	**4**
S	**3**	**4**	**5**

The complete classification of the items on the basis of FNS-HML Matrix is done and tabulated in the proper manner.

4.3.3 Standardization

Upon the analyses of data and classifying the items on the basis of their importance, some standards were set on how to keep the workplace organized and easily accessible to anyone. For that very purpose, it was necessary to communicate the change to workers directly interacting the workplace, an explanatory session was held to educate the workers about the new standards. Moreover, the explanatory charts were also displayed in the color kitchen for the ease of workers so that and any possible difficulty could be avoided.

4.4 Benefits in Terms of Wastages

All the activities that were identified as wastages and then improvised by using lean techniques of SMED and 5S were among the seven wastages mentioned in lean manufacturing. The primary wastages that we dealt with were transportation, waiting time and inventory. Firstly the transportation where the main activities that fell under this category were: (a) placement of drums, which was used to be done manually without trolleys by rolling the drums toward machine; (b) placement of holders was used to be carried out by two labors at a time, carrying the holders which wasted a lot of time. Secondly the waiting time where the activities in the category of waiting time were: (a) removal of screens after the machine completely stops, making it an internal activity was wasteful and potential to be transferred to external; (b) removal of holders was also an internal activity which was converted to internal by applying SMED. Lastly the inventory where the unorganized arrangement of the items in color kitchen, where more than required items were kept all the time, this wastage was removed by using 5S in orderly arrangement of the items.

4.5 Comparison of Output Before and After the Implementations

Under the present heading, changeover time before and after the implementation of SMED and 5S was compared. Furthermore, the pictures of the

4.5.1 Changeover Time

Followed by the implementation of SMED and integrating 5S with it, the results were evaluated and compared. Evaluating the proposed methods is extremely important part because it shows the feasibility of suggested techniques. This part is important because it lets the management decide that whether the suggested methods are capable enough to be standardized for a longer run or not. After implementing the SMED, the pilot runs were carried out to test the propositions which showed immensely positive results as can be seen in table 8.

Table 8. Comparison of scenarios before and after the implementation of SMED

Activities	Duration Before SMED (min.)	Duration After SMED (min.)	Time Saved (min(%))
Drum placement	9	4.2	4.8(53.33%)
Holder removal	9	3.2	5.8(64.44%)

Screen removal	11	5	6(54.55%)
Drum removal	6	2.1	3.9(65.00%)

Thus it was observed that by making these modifications the changeover times could be reduced to a great extent. At the same time, time saved can be utilized in more productive tasks. There are almost 5 to 6 changeovers per day more or less, if around 18% of the time can be reduced in every changeover it would be a great a deal of time saved daily, weekly, monthly, quarterly and yearlybasis.

In last, the comparison of results and achievements before and after SMED were made to ensure the effectiveness of SMED on the BFPM. After eliminating the bottleneck activities and rearranging the methods to perform activities, a noticeable reduction of 18% of the changeover time was observed. The previous changeover time of 142 minutes was now reduced to 117 minutes, which will definitely lead to greater benefits not only in terms of time but in cost reduction, timely order fulfillment and many more.

4.5.2 Output of SMED Implementation

Transportation of drums to the machine should be done by using trolleys instead of manual transportation of each drum individually to avoid the wastage of time.

In the same way, the transportation of holders to be ensured by using trolleys instead of manual transportation. The batcher for next order must be found out during the previous run and placed as near to the point where it is installed as possible, before the changeover starts.

4.5.3 Output of 5S Implementation

There was an unorganized arrangement of the items in color kitchen, where more than required items were kept all the time. This wastage was minimized by using 5S in orderly arrangement of the items. After the implementation of 5S, look of color kitchen was changed from the total mess to the well organized one.

5. Discussion

In order to survive in this sort of market any type of commercial system has to lower prices and all at once produce quality items. The best means to reduce expenses will certainly be with implementing renovations in your manufacturing procedure (Godina et al., 2018). Organizations are increasingly required to have a high degree of quality and versatility in manufacturing (Sousa et al., 2018). SMED is the lean tool which is utilized to manage the reduction of machine changeover times. Changeover Time (COT) is specified as a period in between the last excellent item from previous production orders leaving the equipment and the first good item appearing from the adhering to production orders (Nakeenopakun & Aue-U-lan, 2020). As all continual improvement strategies, SMED needs measurement, control, comparison as well as benchmarking (Antunes et al., 2016). In previous studies, an enhancement that can be made use of to reduce waste is to lower the internal set up time to an external setup utilizing the SMED method (Haifa & Permatasari, 2020). Haifa and also Permatasari (2020) obtained time efficiency by decreasing internal tasks by use of SMED method (Haifa & Permatasari, 2020).Karam et alia (2018) reduced changeover time by 30% in twelve month in Romanian pharmaceutical industry along with the economic take advantage of the SMED execution, process quality, standardization as well as team effort have actually been enhanced (Karam et al., 2018). Sousa et alia (2018) applied SMED technique in such a way to lower the downtime triggered by device modifications, as well as a decrease of 43% in overall changeover time was gotten (Sousa et al., 2018).Hidayat et al (2020) reduced equipment configuration time from 5,938 minutes/month to 3,008 minutes/month by the execution of SMED (Hidayat et al., 2020).Kusrini as well as Parmasari (2020) raised performance from 60,81% to 70,20% at UTC by using SMED technique and also FIVE (Kusrini & Parmasari, 2020).Bimantoro et al (2020) minimized the configuration components on the WEB equipment from 38 task aspects to 32 configuration elements, while on the TSK machine decreasing from 51 activity components to 34 setup elemens. The 5S idea itself can decreasing configuration time on a WEB machine to 31.47% and also TSK machine to 49.31% (Bimantoro et al., 2020).Mulyana as well as Hasibuan (2017) decreased downtime machine punching time from 44.90 hrs to 10.96 hrs or in easy words they decreased configuration time upto 75.59% (Mulyana & Hasibuan, 2017).Nakeenopakun and also Aue-u-lan (2020) used the SMED method and also verified with different wheel models; outcomes showed that almost 60 percent of the forming dies can be minimized (Nakeenopakun & Aue-U-lan, 2020). Ahmad and also Soberi (2018) share their actual sector experience where they implemented SMED technique and also their outcomes indicated that the changeover time was lowered to 44% and interior kind tasks time is lowered to 48% (Ahmad & Soberi, 2018).Herlambang (2020) verified that by applying SMED strategy in electronic devices companies, it can lower changeover time by up to 41% (Herlambang, 2020). In a previous

study conducted by Karam et al. (2018), it was discovered that SMED application can lower the ordinary change gradually, and also the standard deviation from the ordinary time can be reduced. Nonetheless, the value of the capacity process has not been talked about extra deeply (Karam et al., 2018).Sabadka et al (2017) showed significant decrease in hold-up arising out of machine setting time, batch-setting time as well as demo hold-up (Sabadka et al., 2017).Veres et al (2018) suggested the positive relationship between FIVE Level as well as Productivity in a vehicle wire manufacturing plant, as well as the goals defined at the beginning has been met. This implies that carrying out as well as keeping FIVE approach and also requirements in the company causes boosted efficiencies (Veres et al., 2018). Ashraf et al (2017) accomplished a lots of advantages such as area saving, money saving, enhancing performance, lowering rejection of parts by execution of 5S strategy (Ashraf et al., 2017). In the here and now research study, SMED and also 5S methods were made use of for optimizing the changeover time of BFPM. In addition, after removing the barrier tasks as well as reorganizing the techniques to execute tasks, a recognizable decrease of 18% of the changeover time was observed. The previous changeover time of 142 minutes was currently reduced to 117 minutes, which will most definitely cause higher benefits not just in terms of time however in cost decrease, timely order gratification and also many more.

6. Conclusion

This research has identified and uncovered different perspective of changeovers, internal and external as well as value added and non-value-added activities and their consequences on overall productivity.This study focuses on the critical factor of production system such as changeover and suggest ideas to reduce the time duration of changeover to cope with longer changeover time issue. It also emphasizes on the activities that are related to cause changeover delays. Earlier the changeover time of flatbed printing machine was about 142 minutes but now by applying SMED, an essential lean technique and by solving the confronting problems of the changeover, the time spent in changeover is almost 117 minutes. It means that there is reduction in Changeover time now. This study can be used as an effective tool for any industry if the general procedure is applied and expected confronting problems are considered. Nowadays many businesses whether it be service industry or manufacturing industry, their success is truly based on how in the best way they manage and maintain their time and resources. Therefore, in this modern era, the goal of many research studies is to innovate many of such techniques that could help in optimum utilization of the resources and to manipulate the tasks to be completed in minimum time period.

7. Future Implications

Due to smaller span of time, the researchers only focused on time study and somehow method study. There was still space for the analysis of macro motion and micro motion study of workers for various operation. Motion study will lead to less fatigue of workers and operation time will also be optimized.

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Conflict Of Interest

No conflict of the interest was found among the authors of the present research.

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