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OPTIMIZING THE WORK ENVIRONMENT USING LEAN AND CONTINUOUS IMPROVEMENT TOOLS-PRINTING FLOOR

MANIVANNAN SAMPATH
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POLITÉCNICO
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Dissertation presented to ISEP – School of Engineering to fulfill the requirements necessary to obtain a master's degree in mechanical engineering, carried out under the guidance of Professor Raul Duarte Salgueiral Gomes Campilho and Professor Francisco Jose Gomes da Silva.

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KEYWORDS

5s, PDCA, SMED, waste, Muda, lean and continuous improvement tools.

ABSTRACT

The study aims at solving the problems reported by the management using lean tools and continuous improvement tools. The purpose of using a lean tool is to configure the working process involved in production thereby reducing waste periodically. The tool also aims at improving the flow of process resulting in reducing the uneven workflow throughout the floor. The pull system from Kanban also found to improvise flow of materials at the production floor. The continuous improvement tool helps in streamlining works related to implementing works and reducing waste. In this work, the implementation of 5s has found its use in creating a tool room and tool chart along with a pull system introduced for the tools at the pegboard. The use of Kanban cards as pull system at tool chart for the tool is to monitor the flow of tool to the production units at the printing floor. The implementation of 5s in paint room is to organize the ink tins used for setup activity in the production process and to make the ink tins easier to find for the operator. PDCA (plan, do check, act) cycle one of the continuous improvement tools implemented for organizing the printing plates into a system by creating and thereby reducing the retrieval time of the plates by the operators. SMED (single minute exchange of die) performed on production units to find the activities involved in the setup operations and reducing the time needed to perform the setup operations. The results of the implementations made found to be satisfying that the tool room kept periodically and the use of Kanban cards on the tool chart for some tool being used through inspections performed. The systems implemented for organizing the printing plates helped in retrieving the plates from the system for a setup operation seem to have reduced from 17 minutes to 3 minutes. The implementation of 5s at the paint room in organizing the ink tins proven useful as the time needed for operators in obtaining the ink tins and introducing it into the system, a setup operation performed for production purpose observed during SMED process.

PALAVRAS CHAVE

5s, PDCA, SMED, resíduos, Muda, ferramentas de melhoria contínua e enxuta.

RESUMO

O objetivo do estudo é resolver os problemas relatados pelo gerenciamento utilizando ferramentas enxutas e ferramentas de melhoria contínua. O propósito de usar uma ferramenta enxuta é configurar o processo de trabalho envolvido na produção, reduzindo assim o desperdício periodicamente. A ferramenta também visa melhorar o fluxo do processo, resultando na redução do fluxo de trabalho irregular em todo o piso. O sistema de tração do Kanban também descobriu improvisar o fluxo de materiais no chão de fábrica. A ferramenta de melhoria contínua ajuda na racionalização de trabalhos relacionados à implementação de obras e redução de desperdício. Neste trabalho, a implementação do 5s encontrou seu uso na criação de uma sala de ferramentas e um gráfico de ferramentas, juntamente com um sistema de tração introduzido para as ferramentas no pegboard. O uso de cartões Kanban como sistema pull no quadro de ferramentas da ferramenta é monitorar o fluxo da ferramenta para as unidades de produção no chão de impressão. A implementação do 5s na sala de pintura é organizar as latas de tingimento usadas para a atividade de configuração no processo de produção e tornar as latas de tingimento mais fáceis de encontrar para o operador. O PDCA (plan, do check, act) aciona uma das ferramentas de melhoria contínua implementadas para organizar as chapas de impressão em um sistema, criando e reduzindo o tempo de recuperação das chapas pelos operadores. SMED (single minute exchange of die) realizado nas unidades de produção para localizar as atividades envolvidas nas operações de configuração e reduzir o tempo necessário para executar as operações de configuração. Os resultados das implementações realizadas demonstraram ser satisfatórios que a sala de ferramentas é mantida periodicamente e o uso de cartões Kanban na tabela de ferramentas para alguma ferramenta sendo usada através de inspeções realizadas. Os sistemas implementados para organizar as chapas de impressão ajudaram a recuperar as chapas do sistema para que uma operação de configuração parecesse ter reduzido de 17 minutos para 3 minutos. A implementação de 5s na sala de pintura organizou as tintas de tingimento, comprovadamente úteis como o tempo necessário para os operadores obterem as tintas de corante e introduzi-las no sistema, uma operação de configuração realizada para fins de produção observada durante o processo SMED.

LIST OF SYMBOLS AND ABBREVIATIONS

List of abbreviations

GSM	Grams per Square Meter
NVAA	Non-Value Added Activities
OEE	Overall Equipment Effectiveness
PDCA	Plan Do Check Act
SME	Small Machine Enterprise
SMED	Single Minute Exchange of DIE
SPH	Sheets per Hour
TFM	Total Flow Management

List of units

cm	Centimeter
m	Meter
mm	Millimeter
OZ	Ounces

List of symbols

€	Euro

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INTRODUCTION

1.1 Framework

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1.3 Methodology

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1 INTRODUCTION

1.1 Framework

The graphic arts industry where the work is performed has production lines performing jobs of everyday demands of the clients. This includes process from creating the products according to client's preference followed by cutting, binding, lamination until the final product is met. The working conditions are affected by busy long-term production during various scenarios where the implementation of the lean tools and continuous improvement tools are necessary to improve the working conditions, availability of resources and thereby increasing the productivity gradually.

1.2 Objectives

The objective of this thesis is to improve the conditions at Marsil with the help of lean tools and continuous improvement tools by,

- Creating a tool room for the machinery works to take place and to create a tool chart for organizing tools.
- Creating a system for organizing the ink tins in the paint room.
- Implementing a system for the printing plates to be organized and quick retrieval of the plates from the system for the printing jobs.

1.3 Methodology

- Study about the problem reported.
- Collection of data about the problem and proposing ideas in solving them.
- Study about the production floor and the included production units and their works.
- Brainstorming on the problems in figuring out the possible causes and to get a broader perspective in structuring the solutions.
- Selection of idea based on collected data, available area, resources.
- Implementation of an idea based on the adopted tool.
- Collection of data after implementation.
- Analyzing the data obtained.

1.4 Thesis structure

The thesis is structured by having it into two sections,

- The theoretical background is having the study of the printing sector, the importance of printing in the economy, types of printing, printing equipment, printing process with the description of each and their applications, the evolution of offset printing.
  Production lines: include the concept of the production line, types of production lines and management of production lines.
  Lean tools and concept include waste concept, poke-yoke method, Muda, single minute exchange of ink, 5s and continuous improvement tools has brief explanation on PDCA (Plan, do, check, act), TFM (Total flow management), OEE (Overall Equipment Effectiveness) from various research papers, journals, books, and websites.
- The development section will have characteristics of the production lines, addressing the problems at the printing floor reported by the company, goals, performing brainstorming actions on the problems by figuring out the elements involved in the cause and suggesting out the actions, SWOT (strengths, weakness, opportunity, and threats) involved in these actions. Later, the actions implemented according to lean tools and continuous improvement tools necessary.

1.5 Host company

The company Marsil was founded in the year 1953 as a printing business licensed for the manual cutter and a printing machine in the downtown of Porto, Rua Conde de Vizela, No. 76. In the early 80s, after the formation of the company, became the first customer segmentation exercise and went on to emphasize to the institutional client initially Banco Borges & Brother, followed by Banco Espírito Santo. The company now also has a delegation in Lisbon, initially at Av. Infante Santo and later in Tower 2 of the Amoreiras, which still remains, to provide the necessary personalized support to the customer.

The company was awarded the prize of IAPMEI SME Excellence in 2000 and 2001, which happened again in 2008 and 2009 with the awards SME Leader and SME Excellence, respectively.

In 2006 Marsil started a new business area, passing by incorporating value-added services to the graphics product - the Bursar and Logistics Management, with stock management graphics, delivering the quantity needed time limit and at the locations by customers.

In 2008 it was inaugurated Mosteiró facilities with a park web presses and finishing lines, constituting the second productive hub and, from 2010 onwards, there is an ongoing new customer segmentation exercise and exploration of new markets, which has allowed the Marsil increase the portfolio and even be honored with some awards and prestigious honors in the field of Graphic Arts.

Marsil currently has 1420 clients currently active, and half of them made orders during the year 2016. Noteworthy are clients like the Caixa Geral de Depósitos, Novo Banco, Millenium BCP, SantaderTotta, Banco BPI, Euro big, Pestana Group Hotels, Hotels Minor / Tivoli, Nau Hotels Group, Eurostars Group Hospital da Luz, among other clients in these and other sectors such as footwear, textiles, etc. The Marsil has forty-two employees employed at present.

BIBLIOGRAPHIC WORK

2 THEORETICAL BACKGROUND

2.1 The printing sector

The printing industry covers the entire print process from creation through distribution to other non-print services that it offers. So, any definition of the industry includes not only the numerous firms that perform the actual printing but the companies that provide binding and finishing services such as cutting, trimming, die to cut, laminating, mounting and varnishing documents for their clients [1].

A wide range of products is produced in the printing industry. In addition to magazines, books, and some small newspapers, other examples of printed products include direct mail, labels, manuals, and marketing material. Less obvious printed goods include memo pads, business order forms, checks, maps, T-shirts, and packaging. The industry also includes establishments that give quick printing of documents for the consumer or support services, such as prepress, embossing, binding, finishing, and mailing [2].

2.1.1 Importance in the national and international economy

The printing press had enormous effects on the economy. The printing press was an invention that led to the flourishment of trade throughout all of Europe due to increased demands. This was a cause for a stronger economy. Also, a more natural way to print books led to more affordable books, this meant that now not only could the elite and wealthy afford books but so could the poor. More durable and well-made books grew the market for books and strengthened the economy. Newspaper, on the other hand, were more everyday items created by the printing press which caused a massive burst in demand for newspapers. Frequent changing of prices downward made more affordable books. Books carried information for people to learn and create more jobs. Stores could now sell and buy books more rapidly. The demand for books and newspapers also led to more inventions for printing to grow the economy. Lastly, printing became a massive industry and led to different companies to move into large noisy factories, meaning many for jobs to hire, more books to make, and more books to sell [3].

Historians and studies suggest the printing press was one of the most revolutionary inventions in human history as well the printing press eased these intellectual developments, the process of sharing and recombining ideas that economists have tied to technological progress, and the development of economic activities in which literacy, numeracy, and other intellectual skills were valuable. Indeed, there is an argument to be made that (via its pervasive and fundamental impact on a wide range of economic activities) printing technology may qualify as a general-purpose technology [4].

Printing cities enjoy helps due to agglomeration economies. The printing press produced new face-to-face interactions in addition to books and pamphlets. Printers' workshops brought scholars, merchants, craftsmen, and mechanics together for the first time in a commercial environment, eroding a pre-existing "town and gown" divide. Bookshops and the houses of printers became meeting places and temporary residences for intellectuals. Print technology also produced, printing-scholars, Adapt to handling machines and marketing products, finding learned societies, promoting artists and authors advancing new forms of data collection [5].

Cities with printing presses derived benefits from the technology that others did not. The costs of information and human capital accumulation were significantly lower in cities with printing presses. In part, these advantages were due to transport costs. Print media is costly to transport because it is vast and a fragile commodity, sensitive to damp [6].

[4]Jeremiah Dittmar in comparing cities where printers set up presses to similar cities where they did not conclude that "print technologies had very substantial effects in European economic history through their impact on cities "Some have concluded that the economic impact of the printing press was limited.

Figure 1 Cities with printing in 1450 [4].

Figure 2 Cities with printing press from the 1500s to 1800s [4].

Figure 1 and Figure 2 represents the cities with printing presses at the 1450s and between 1500s-1800s.

On exploiting the city level data on the diffusion and adoption of the printing press to examine the technology's impact from a new perspective, shows that cities that adopted the printing press in the late 1400s enjoyed no growth advantages prior to adoption, but grew at least 20 percentage points {and as much as 80 percentage points} more than similar cities that did not change over the period 1500-1600. These estimates imply that the impact of printing accounted for at least 18 and as much as 80 percent of European city growth between 1500 and 1600 [4].

Cities that were early adopters of the printing press kept a significant growth advantage even over the three hundred years running 1500-1800. Even 1500-1800, print accounted for somewhere between 5 and 45 percent of city growth. Between 1500 and 1800, European cities were seedbeds of the ideas, activities, and social groups that launched modern, capitalist economic growth [4].

2.1.2 Types of printings

1. Flexography,
2. Letterpress printing,
3. Screen printing,
4. Rotogravure,
5. Digital printing,
6. Lithography.

2.1.3 Printing equipment

Industrial printing equipment and supplies include screen printing equipment, digital printing equipment, label printing equipment, offset printing equipment, letterpress printing equipment, and flexographic printing equipment.

Table 1 Describes various printing equipments and their associated equipments.

Table 1 printing equipment features [7].

Serial Number	Equipment used for printing	Definition	Features
1	Flexographic printing equipment	Flexographic printing equipment uses rubber cylinders that are easy to keep and repair.	• Viscosity control systems, • Ink pumps, • Chamber doctor blades, • Video systems, • Stroboscopes, • Slitting and rewinding machines.
2	Letterpress printing equipment	Letterpress printing inks type that is pressed onto the printing surface.	• Die cutters, • Scorers, • Engravers, • Embossers, • Foil stampers, • Binders.
3	Screen printing equipment	Screen printing equipment uses rubber cylinders that are easy to keep and repair.	• Racks, • Stretchers, • Transfer presses, • Dip tanks, • Dryers.
4	Digital printing equipment	Digital printing equipment produces printed materials directly from a computer file and does not use intermediate materials such as film or plates	• Variable imaging digital presses (computer to paper), • Digital desktop printers, • Digital copiers, • Direct imaging presses (computer to plate on press).

5	Offset printing equipment	Offset printing equipment produces printed images from plate to paper with the help of inks and cylinders.	• Printers, • Scanners, • Folding machines, • Joggers, • Binding equipment.

2.1.4 Printing process description

This section briefly explains the process involved in various printing techniques and their uses in production activities.

2.1.4.1 Flexography

Process

Flexographic printing involves a "plate cylinder" covered in whole or in part with raised flexible print media that carry ink for an image. The media then deposit that ink onto the substrate. Initially, the media made of rubber sheets pressed into rigid molds and vulcanized. shows the image of flexography printing unit and its working components.

Figure 3 shows the working image of flexography printing unit with its components.

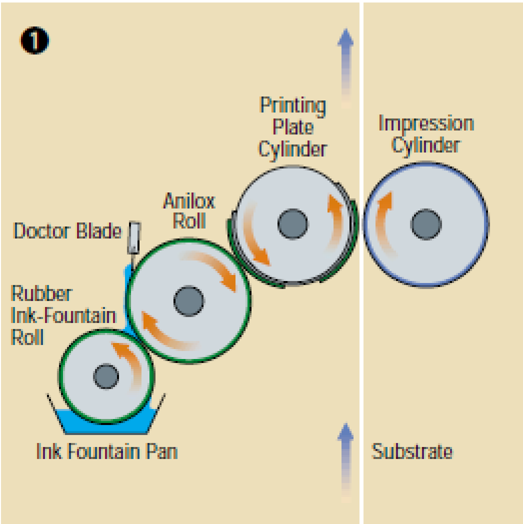


Figure 3 Flexography printing station [8].

A metal (e.g., magnesium) plate exposed with the negative of the image to be printed and developed in an acid bath creates the first mold. This metal relief plate makes the mold for commercial use (usually in Bakelite plastic). A rubber or plastic sheet material is vulcanized (by pressing it into the metal mold under controlled temperature and pressure) to create the printing plate. Alternatively, a photopolymer material exposed to the negative of the image to be printed creates the print media directly. Light not excluded by the negative image cross-links the polymer. In the following step, a liquid bath removes the polymer not cross-linked during the exposure process. Raised surfaces of (crossed-linked) photopolymer material give the raised surfaces to carry ink. Recently, direct laser light exposure of photopolymer material has been able to cut the need for the intermediate contrary giving high reproducibility and quality [9].

The process was developed primarily for printing on packaging substrates board, paper, foil, and film. Materials are supplied in roll form for feeding into form-fill, over-wrapping, bag making, and other continuous web processing machinery [8].

Flexography printing is an efficient, cost-effective and versatile printing method. by the end of the 1990's, approximately one-quarter of all printing is flexographic; in the packing segment of the printing industry. Flexography enjoys a market share of over 65% growth throughout the 1990's has been steady [8].

Applications

Some typical applications for flexography are paper and plastic bags, milk cartons, disposable cups, and candy bar wrappers. Flexography printing may also be used for envelopes, labels, and newspapers [8]. Figure 4 shows some of the applications where flexographic printing is used. The labels of the above-shown products are made through flexographic printing.

Figure 4 Flexography printing application [8].

2.1.4.2 Letter press printing

Process

Letter-press printing consists, printing of suitably aqueous ink onto a sheet or web from surfaces in relief. The printing form is usually a stereotype or electrotype plate, or a type form with or without etchings bearing designs etched in relief. While various kinds of presses may be employed, rotary presses are used for high-speed letter-press printing, as in the printing of books, magazines, newspapers. In rotary letter-press operations, a supply of ink is maintained in an ink fountain at a consistency suitable for the printing conditions, and the ink is fed from the fountain and distributed onto the raised surfaces of the rotating printing form by a series of transfer and inking rollers [10]. The web to be printed is passed into contact with the moving inked form to affect the printing operation. After one side of the web has been printed, that is, after the first impression, a second printing, or second impression, is usually made on the other side of the web by continuous operation of another section of the same press. In multi-color letter-press printing, a series of impressions are made with inks of assorted colors, a plurality of impressions being placed in adjacent or superimposed relation on the same side of the sheet or web [10].

Figure 5 shows the working of letterpress printing unit and its components.

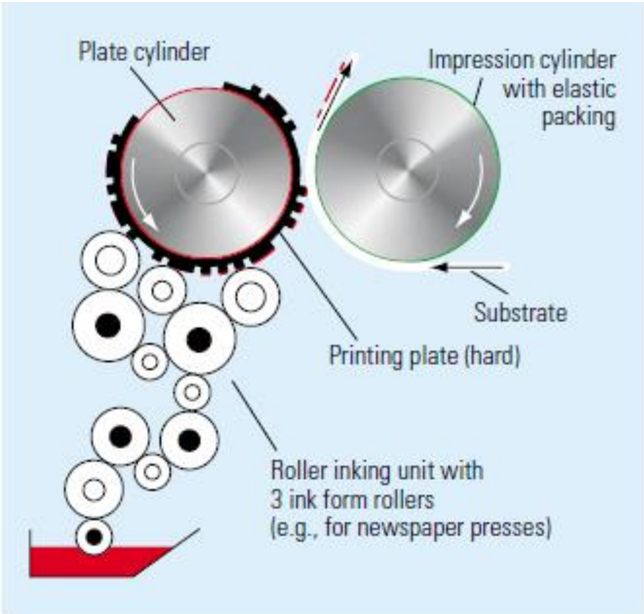


Figure 5 Letter printing station [10].

Applications

Letterpress printing was the effective book-preparing process. For four centuries it was also the powerful printing technology for posters, announcements, printed matter for churches, government, and businesses, single or two paged local news sheets, daily and weekly newspapers as well as various simple print jobs. now limited to specialty works such as numbering, embossing, hot stamping and hot wax carbonizing (spot carbon printing). It is also used for die cutting, perforating, slitting and scoring [11].

2.1.4.3 Screen printing

Screen printing is a process in which ink is forced through a screen. The screen-printing stencil serves as a printing plate. The screen is a delicate fabric made of natural silk, plastic, or metal fibers/threads. Plastic or metal fabric is used nowadays. Ink is imprinted/transferred through the image-specific, open mesh that is not covered by the stencil. The screen-printing plate is, therefore, a combination of screen and stencil. It is the material, the fineness of the screen (the number of screen threads per centimeter of fabric length), the thickness of the screen, the distance between the top and bottom sides of the screen, and the degree of opening of the screen (the degree of screen opening areas as a percentage describes the ratio of the total of all mesh openings to the entire surface of the fabric) that determine the printing properties and Quality of the fabric (screen) [11].

Applications

Textiles/materials, printed T-shirts, printed toys, fronts of televisions, radios, etc., automobile dashboards, measuring equipment, packaging (plastic bags), printed circuit boards, large-format advertising posters are the areas where screen printing have found its use [11].

Figure 6 shows the image of the screen-printing process and involved components.

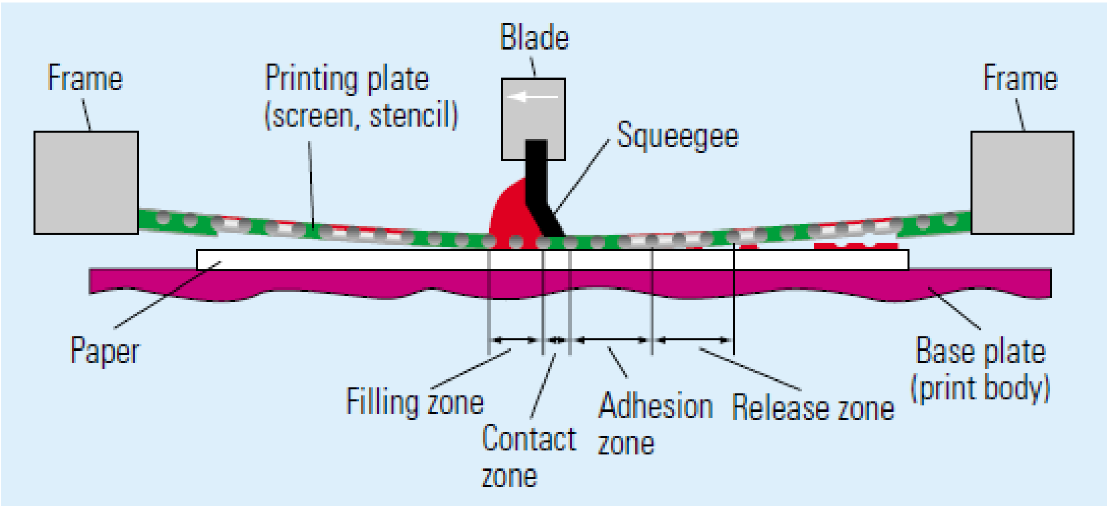


Figure 6 Screen printing station [11].

2.1.4.4 Rotogravure

Process

True intaglio or steel-die process prints from sunken lines or grooves are connected and cross each other. Ink is then applied to the engraved areas and doctored or wiped off the flat nonimage areas. The resulting ink image is then impressed on the substrate to be printed. Paper currency is printed from steel dies capable of reproducing beautiful lines that no other process can duplicate. A rotogravure is a form of printing and prints directly from unconnected cells engraved into the plate cylinder [8].

Figure 7 shows the image of Gravure printing process and its units in operation.

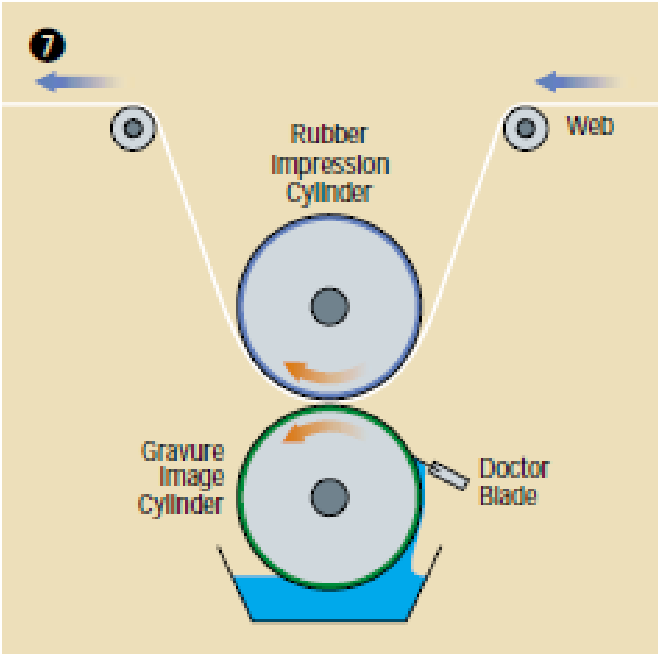


Figure 7 Gravure printing station [8].

Applications

Gravure is used for packaging, magazines, newspapers, and other specialty printing applications. It has been an outstanding choice for printing process color for mass-circulation magazines and newspapers. Gravure-printed postage stamps are another example of the exceptional print results of rotogravure. Many plants have blended flexography with gravure to produce exceptional print results on packaging materials [8].

2.1.4.5 Digital printing

The basic concept is that digital means using numbers to represent something, and that's what a computer does. A typical image is converted into numerical data (a long string of ones and zeros) that describe or quantify each sample point or "pixel" (short for picture element, the basic unit of image information) in terms of specific attributes such as color and intensity. This data can be stored, manipulated, and transformed with digital printing technologies back into a customarily viewed image [12].

Process

Compared to traditional printing techniques digital printing is different. However, there is no pressure or impact, and there is no physical matrix. The matrix now sits in the computer in the form of digital data that can be converted repeatedly, with or without any variation, into a print by any image-maker who either does his own printing (“self-printing”) or who uses an outside printing service, lab, or retailer [12].

Figure 8 shows the process in which data is created, stored and finally processed to produce printed image on sheet.

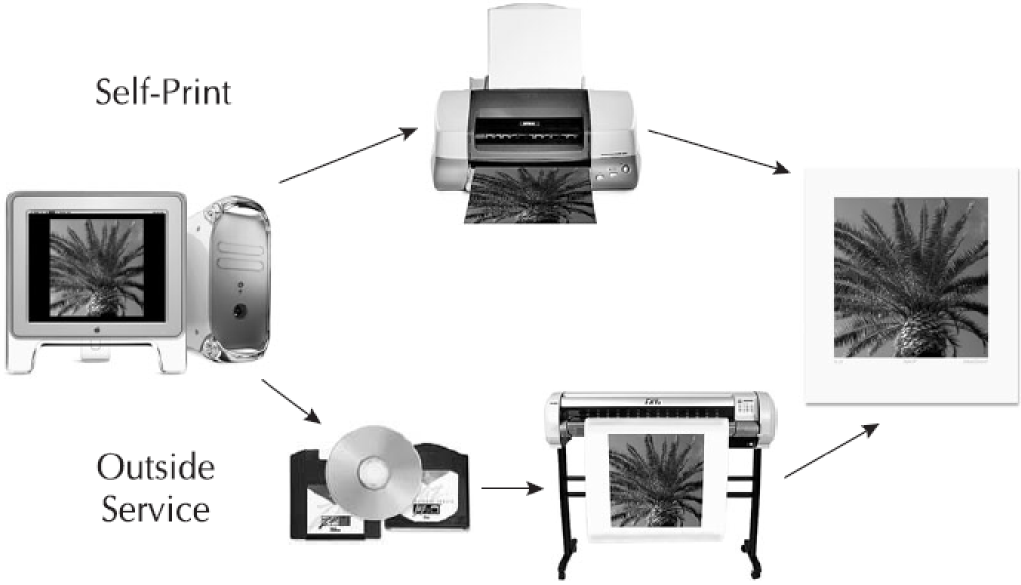


Figure 8 Processing of data into printed image [12].

Digital imaging and printing have changed the rules of visual communication. Making original prints or reproductions (see below), especially at an enormous size and in color, used to be costly, cumbersome, or difficult for any individual photographer or artist [12].

Figure 9 shows the image created using digital printing.

Figure 9 shows the image created using printing [12].

Advantages

The advantages of digital printing are clear in terms of, cost, consistency, storage, flexibility.

- Some of the digital printing technologies are line printing — where pre-formed characters are applied to the paper by lines.
- daisy wheel — where pre-formed characters are applied individually.
- dot-matrix — which produces arbitrary patterns of dots with an array of printing studs.
- heat transfer — like early fax machines or modern receipt printers that apply heat to special paper, which turns black to form the printed image.
- blueprint — and related chemical technologies.
- inkjet — including bubble-jet — where ink is sprayed onto the paper to create the desired image.
- laser — where toner consisting primarily of polymer with the pigment of the desired colors are melted and applied directly to the paper to create the desired image.
- 3D printing.

2.1.4.6 Offset lithography

Process

In offset lithographic printing the Printing ink is supplied to the inking rollers via a reservoir (duct). Greater and lesser amounts of ink can be fed to the inking rollers by opening and closing duct keys. The inking rollers transfer the required amount of ink to the printing plate. The printing image is then transferred (or offset) from the plate to the `blanket` and then to the paper on the impression cylinder. The printed sheet is then passed into the next printing unit via the transfer cylinder. Each color must have a separate printing unit. The printing plate is made from aluminum and backed with a sensitive coating. The plate has two distinct areas; the image area and the non-image area. Ink is accepted by the image areas of the plate while the non-image areas accept a water-based mix called a damper solution. When applied to the plate the solution repels ink from the non-image area [13].

There are two types of lithographic printing, they are,

- Sheet-fed

Sheet-fed press prints an image on single sheets of paper as they are fed individually into the press. The print quality and sheet to sheet registration are often better than web-fed printing, but it is often more economical to produce huge runs on web presses because of their higher running speeds.

- Web-fed

  A web-fed press prints images on a continuous web of paper fed into the press from a large roll of paper. The web of paper is then cut into individual sheets after printing or as with continuous business form applications, it is left in web form and is perforated for later separation into individual sheets.

Figure 10 shows the working of offset printing machine along with parts involved in producing prints.

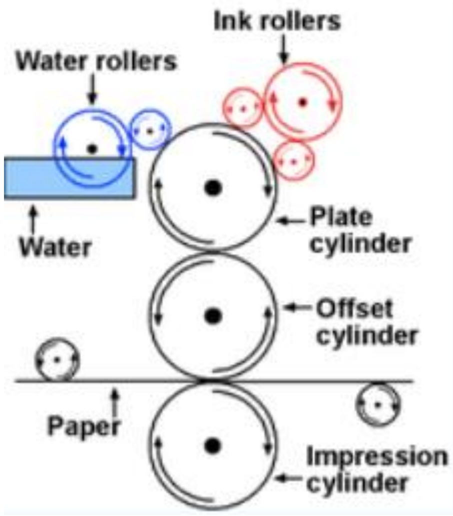


Figure 10 offset printing station [13].

Applications

The highest printing quality for packaging is achieved with offset printing. Accordingly, printing of expensive luxury packaging for individual spirits, chocolates, perfumes, and cosmetics, and even embossing in the correct register is always done on sheet-fed offset presses. The printing of many other cardboard products and folding boxes for the packaging of frozen food, ice cream, cigarettes, drugs, and cosmetics, as well as many other products in the food and non-food areas, remains the almost exclusive domain of offset printing technology [11].

Figure 11 shows the usage of offset printing on various products.

Figure 11 Usage of offset printing for product lables [11].

2.1.5 Evolution of offset printing press

This section shows the evolution of offset printing technology and inventions made over the past 100 years [14] [15].

1875

The first press to use offset lithography and the offset printing process is invented in England. The offset cylinder was covered with specially treated cardboard that transferred the printed image from the litho stone to the surface of the metal.

1880

The cardboard covering of the offset cylinder was changed to rubber, which is still the most commonly used material.

1903

Ira Washington Rubel of the United States used the offset process to print on paper. Rubel noticed that whenever a sheet of paper was not fed into his lithographic press during operation, the stone printed its image to the rubber-covered impression cylinder, and the next impression had an image on both sides, direct litho on the front and an image from the rubber blanket on the back and discovered that images were printed sharply by printing from the stone to the blanket and then to the paper.

1911

Albert Harris observed the process discovered by Rubel at about the same time and developed an offset printing press for the Harris Automatic Press Company.

1950

During the 1950s, offset printing became the most popular form of commercial printing as improvements were made in plates, inks, and paper, maximizing the technique's superior production speed and plate durability. Today, most of the printing, including newspapers, is done by the offset printing process.

1960

Increasingly newspaper printers begin replacing their outdated letterpress machines with offset presses.

1962

Heidelberg begins development for offset printing presses. This came after decades of resistance by management. Technicians were able to convince them that this was the way of the future.

2.2 Production lines

2.2.1 Concept of production line

A production line is a set of the sequential process set up on an industrial shop floor. A production process or a manufacturing process is the transformation of raw materials or components into finished products. The stages of a production process involve procurement, fabrication, assembly, testing, packaging, and distribution. The production or manufacturing lines in industries can be categories into three type's, i.e. automated production lines, semi-automated production lines, and standard production lines. The nature of a production line depends on the complexity of the manufacturing parts, the production volume, the sensitivity of the product and cost [16].

The production system has the following characteristics:

1. Production is an organized activity, so every production system has an aim.
2. The system transforms the various inputs into useful outputs.
3. It does not run in isolation from the other organization system.
4. There exists feedback about the activities, which is essential to control and improve system performance [17].

Figure 12 shows the inputs go through the transformation process and finally the output of a production system.

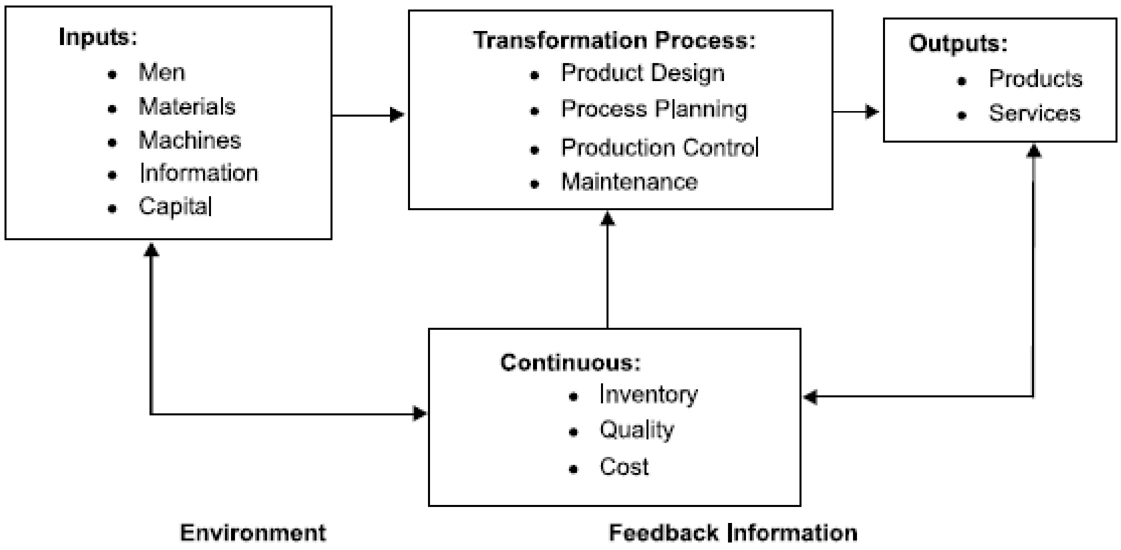


Figure 12 Schematic Production System [17].

2.2.2 Types of production lines

2.2.2.1 Manual production lines

It consists of multiple workstations in which the assembly work is carried out as the product (subassembly) is passed from station to station along the line. At each workstation, one or more human workers perform a part of the total assembly work on the product, by adding one or more components to the existing subassembly. Manual lines are especially common, where workpieces are fragile or if workpieces need to be gripped often, as industrial robots often lack the necessary accuracy. In countries where wage costs are low, manual labor can also be a cost-efficient alternative to expensive automated machinery [18].

Figure 13 depicts the manual assembly line setup.

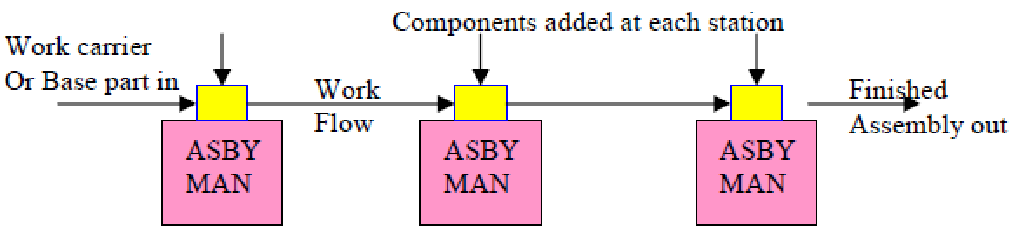


Figure 13 Manual assembly line [18].

Manual operations are used in the assembly of complex work elements as well as when product demand is unstable or where the use of specialized machines and equipment is unjustifiably expensive. Thus, caution must be exercised in the design of a manual assembly line, with respect to the volume flexibility with uncertain production demand. To achieve this situation needs adjusting the number of workers or the system configuration according to the changes in product demand. Hence, a manual assembly line is more flexible than automated machine assembly systems in adapting to the changes in production demand [19].

Manual assembly lines are used in high-production situations where the work to be performed can be divided into small tasks and tasks assigned to the workstations on the line. A key advantage of using manual assembly line is a specialization of labor is by giving each worker a limited set of tasks to do repeatedly. According to Shtub [19], lack of motivation and low level of satisfaction, which is typically caused by the high repetitiveness of elementary operations, have been considered as a significant disadvantage of assembly production.

2.2.2.2 Semi automatic production lines

Semi-automation describes a system in which a human operator or a small production line feeds a product to a robot, the robot performs a single task on that product, and then the human operator removes the product and completes the task.

"Work characteristic of a machine that only needs some degree of support from a man". In contrast to a completely automated system, semi-automation does not achieve complete relief from work for the worker [20]. I.e., the technical system usually achieves the control of the individual functions. Program control, which means the start, end, and succession of the individual functions, is accomplished by man".

Figure 14 shows the integration of manual and automatic workstations.

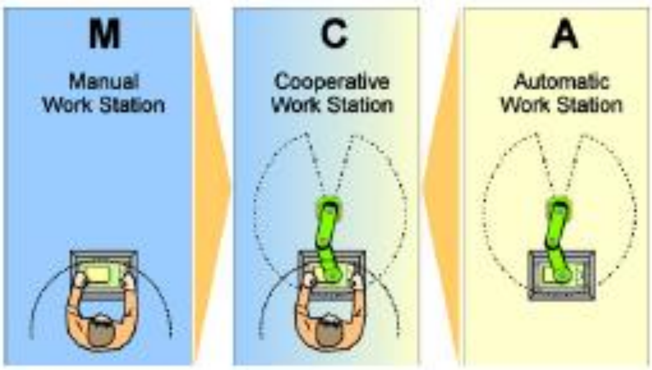


Figure 14 combination of manual and automatic workstations [21].

Utilizing robotic and human capabilities at their best is obtained in an assembly system where there is a sequential division of tasks. The simple tasks suited for robots are found upstream in the line. The complex often varied tasks that give the assembled products human operators downstream perform their individual features. Such hybrid lines have been used to advantage in the industry for more than two decades [21].

Figure 15 shows the workstation been shared by the worker and an automated machine in a line.

A

B

Figure 15 A and B workplace sharing hybrid systems [22].

In this scenario, several components must be assembled on a sheet metal part which is supplied by a conveyor system. The human worker must grip the components out of bins, to transport these parts towards the conveyor system (handling time) and to put the components on the sheet metal parts (assembly). Afterward, the robot must screw these components into the sheet metal part (assembly). If the worker is too slow, the robot will wait until the worker has finished his tasks [23].

2.2.2.3 Automated production lines

An automated production line has multiple workstations that are automated and linked together by a work handling system that transfers parts from one station to the next. The automated production may consist of, automated workstations, manual workstations, and inspection stations.There are different types of configurations layouts available for automated production lines:

- In line,
- Segmented In-Line,
- Rotary.

In-line layout

Raw materials enter the automated production line and undergo a system of automated processing at various workstations along the fixed production line; the parts are passed from workstation to workstation by means of a mechanized work transport system, until the wholly processed parts pass out of the automated production line after the last process occurs to the part at the final workstation in the system [24].

Figure 16 describes the process of the In-line automated production line.

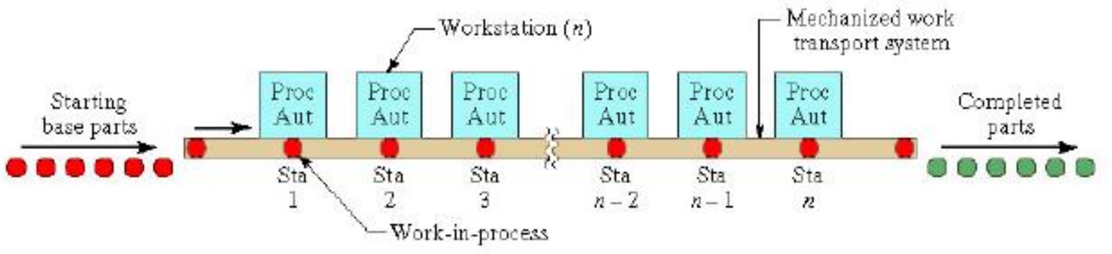


Figure 16 Inline Configuration of an automated production line [24].

The conditions that decide the use of automated production lines include high product demand; stable product design; long product life; and multiple operations.

Segmented In-line

L shaped layout

This layout allows fitting in a lengthy series of operations into limited space. The feeding cells start on an aisle and end at the point of use. This May allow isolation of dangerous or costly-to-move equipment in the elbow, with savings in implementation cost and/or two directions for expansion. It is easy to segregate the in-flow and outflow of physically different materials, products, supplies, and special services [24]. Figure 17 shows the L-shaped production layout with assembly stations to perform work.

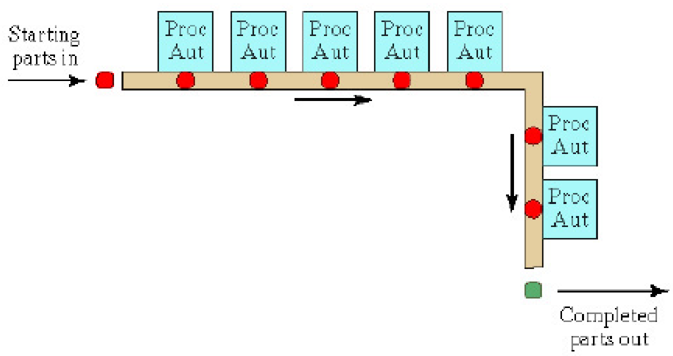


Figure 17 L shaped layout [24].

U- shaped layout

U-shaped production lines were conceived as a solution in lean production environments, for waste elimination and for getting the full use of worker's capabilities. Waste removal is usually achieved by the introduction of pull systems, one-piece flow, leveling, and "jidoka," while fully utilizing workers' capabilities requires a system of respect for people based on minimizing wasted movements, ensuring their safety, and giving them greater responsibility in running and improving their jobs [25].

Figure 18 shows u shaped production line system. In U shaped lines, the entrance and the exit of the line system are remarkably close to each other. Operators may handle work-pieces both on the front and back of the line. What operators found in crossover workstations can perform tasks from both the front and back of the line. Thus, idle times are reduced, and resource use is increased thanks to the crossover stations found in between the front and back of the U line [26].

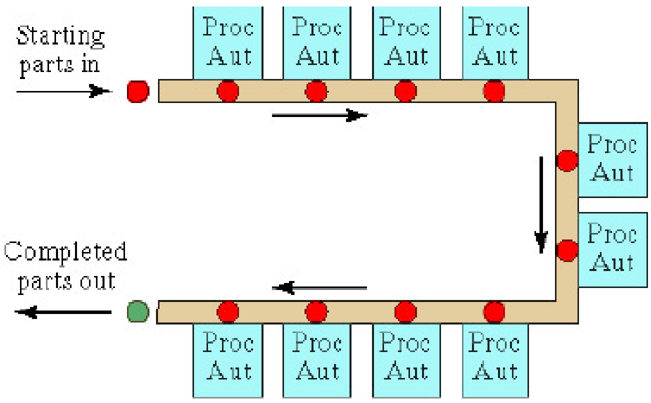


Figure 18 U shaped production layout [24].

Rotary

Consists of a circular worktable around which work parts are fixed to work holders. The worktable rotates to move each work part, in turn, into each automated workstation which is found around the circumference of the worktable. The worktable is often called a dial, and the equipment is referred to as a dial indexing machine, or simply, indexing machine.

Figure 19 shows the image of a rotary layout design.

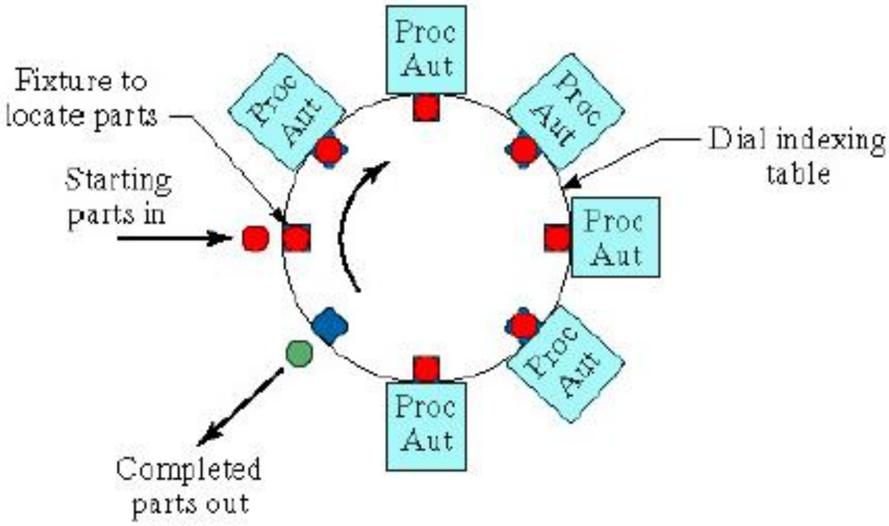


Figure 19 Rotary layout [24].

Limited to smaller work parts and few workstations, and they cannot readily accommodate buffer Robotic production lines storage capacity. However, they need less floor space and are less expensive than other configurations [24].

Robots are being used extensively in assembly lines to perform the tasks, and these assembly lines are called robotic assembly lines [27]. The robots are programmed to perform different types of tasks, and it can be used to work 24 hrs without worries of fatigue. Different types of robots are available in the market to do the same task with different capabilities and efficiencies. Therefore, there is a requirement of reasonable allocation of robots to workstations with the sure specific aim. These robots need to be re-assigned whenever there is a new product is planned for assembly [28].

Michels [29] consider that a robotic assembly line is composed of platform stations and transporter robots to displace work-pieces between these platforms, Multiple robots may be assigned to each platform station. By defining each transporter or platform as a station, and assuming the line starts and finishes with a transporter robot, the configuration results in line with an odd number of stations in an alternating pattern of platform-fixed and transporter robots.

Figure 20 shows the robotic line design model forming 13 serial stations (S1 to S13). There are 24 robots in total, composed of 17 platform robots (15 performing geometry and finishing welding tasks and 2 performing stud tasks) and 7 transporter robots (4 performing finishing welding tasks, 1 performing stud tasks (S9) and 2 for work-pieces handling, in the entrance and S11).

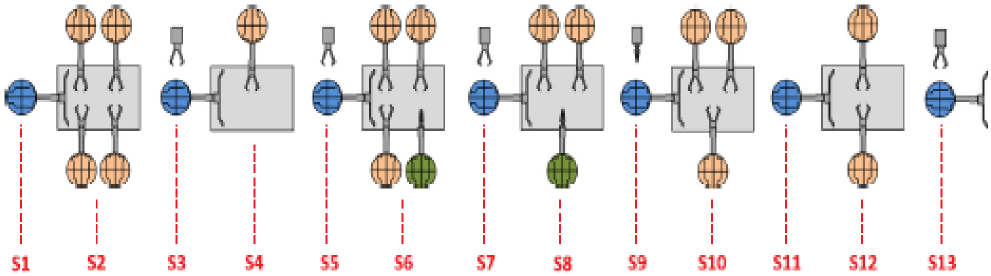


Figure 20 Welding process performed by platform robots [29].

Figure 21 shows the types of the robot and their roles where they are being used in the assembly line.

Element	Description
	Welding robot
	Stud robot
	Transporter robot
	Welding tool
	Stud tool
	Platform station
	Track-motion device

Figure 21 Roles of robots [29].

Figure 22 shows the welding process performed by platform robots.

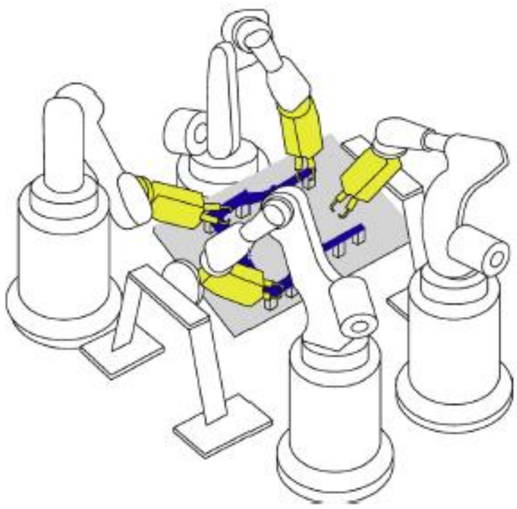


Figure 22 Platform robots performing welding tasks [29].

Figure 23 shows transporter robot on a track motion device unloading workpieces.

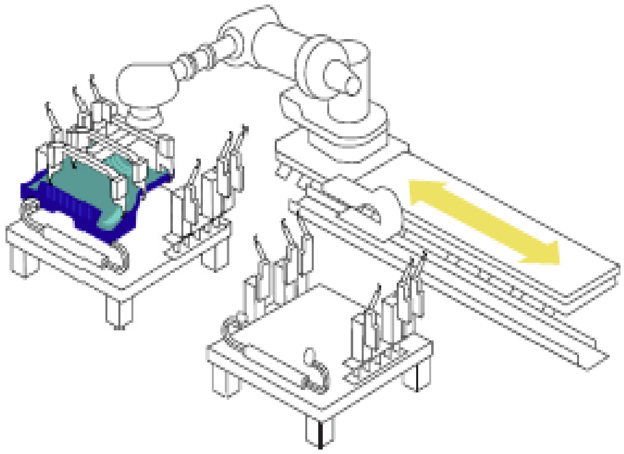


Figure 23 Transporter robot on a track-motion device [29].

Benefits of the robotic system.

- The requirement for reduced floor space,
- Improved efficiency Improved quality,
- The ability to work in cold or hostile environments,
- Increased yields and reduced wastage,
- Increased consistency,
- Increased flexibility for some operations [30].

2.2.3 Management of production lines

2.2.3.1 Workstations

A workstation is among the most critical places in a manufacturing environment. Well-organized working areas are essential for standardized work procedures, which are needed to control the workplace. To perform the required tasks, operators must use different types of equipment, tools, and materials. If the necessary resources are not precisely and safely stored, operators lose precious time to find them, increasing thus the non-value-added time (waste) [31]. Workstations play a critical role in manufacturing processes. Lean workstations focus on minimizing waste and concentrate operators to critical issues. It is essential to ensure effectiveness in an environment of high customization, automation and competitiveness.

As from the workstations design point of view, Workstation design handles placing materials, tools, equipment, etc., and routing operator movements in the most suitable form. That way, operators can perform their work in an efficient manner [31].

traditional workstations and lean workstations are inherently different. Traditional workplaces are designed to ease the work of material handler, not increase the value added by the operator. A lean workstation is designed focused on operator concerns, such as safety and ergonomics, and minimal wasted motion, with the goal to get parts efficiently and find tools quickly. Assembly materials, tools or parts should be strategically positioned to allow the operator to reach it instantaneously, without interfering with operators' safety and comfortability [32].

Maslow [33] introduced five stages of "Hierarchy of workstations needs," which were developed to understand and priorities the requirements to achieve full performance in workstations.

Figure 24 shows the Functionality, effectiveness, efficiency; satisfaction are the levels of hierarchy in workstation needs towards excellence, proposed by Maslow.

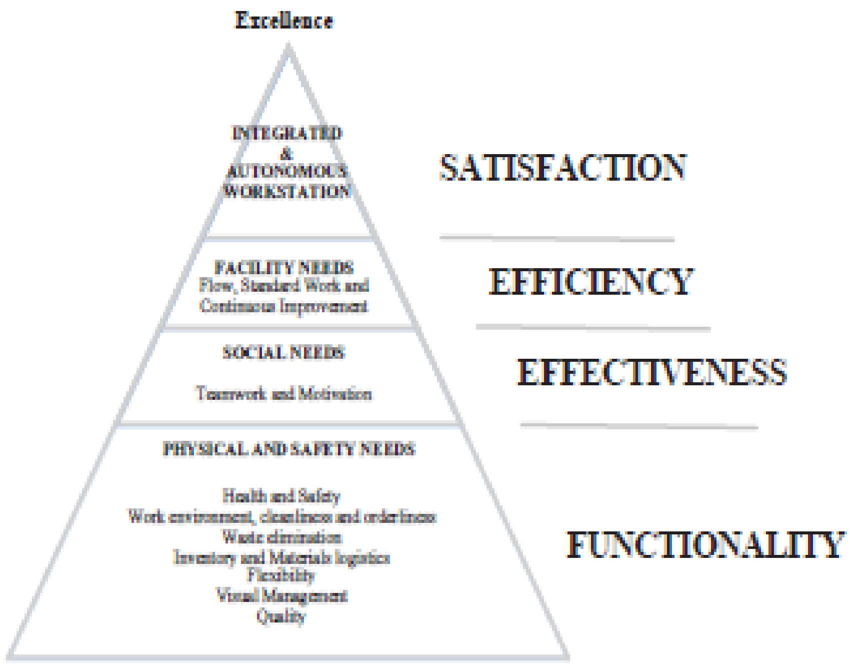


Figure 24 Hierarchy of workstation needs [33].

Functionality ensures physical and safety needs of the operators. Effectiveness fulfills their social and relationship needs, such as friendship, love, and belonging. Efficiency reflects how the workstation and their associates are seen in the whole facility and if their value is recognized and respected by others – esteem. Finally, satisfaction refers to the achievement of higher goals and full levels of satisfaction – self-actualization, and self-transcendence. Once all levels have been fulfilled, the company and its workstation can achieve the desired level of excellence [33].

2.2.3.2 Line balancing

Line balancing is a technique used in connection with the design of product layout or ‘‘lines’’. The term ‘‘balancing’’ is used because one of its main aims is to minimize the idle time and spread it as evenly as possible across the workstations [34]. It is also used to minimize imbalance between/among workers and workloads to achieve the required run rate. Therefore, the line should be analyzed in terms of the assembly process, workstations layout, and workstation cycle time [35].

When balancing a line, the following factors need to be taken into account:

- the required output rate or cycle time (which depends on the demand for the product);
- precedence constraints (these are restrictions on the order in which tasks can be done; in other words, specific tasks will have ‘‘predecessor tasks’’ that must be done first);
- zoning constraints (these are restrictions on where specific tasks or combinations of tasks should, or should not, take place);
- duplication of workstations are done in case when a task takes longer cycle time than the available cycle time [34].

The line-balancing problem forms two aspects:

- Determination of the required number of stations and,
- The assignment of tasks to each station with the aim of maximizing efficiency (by minimizing idle time and spreading it evenly across workstations).

Formulation

Equation 1 Represents the formulations involved in line balancing.

Equation 1 Formulations involved in line balancing.

$$cycletime := (production/unittime)/(demand/unittime)$$

$$Number\ of\ work\ stations\ := Task\ time/Cycle\ time$$

$$Efficiency := Task\ time/Actual\ number\ of\ workstations$$

The effectiveness of the balance decision is measured by the ‘‘balance loss’’ of the line. The balance loss is the time invested in making one product that is lost through imbalance, expressed as a percentage of the total time investment.

For a paced n stage line, the time lost through imbalance is the cumulative difference between the stations’ distributed work times and the cycle time allowed by the pacing of the line. For unpacked lines, it is the cumulative difference between each stage’s work time and that of the stage with the most significant work time (this effectively governs the cycle time of the whole line).

An amazingly simple line-balancing problem may be solved by ‘‘trial and error’’. Most practical problems, however, are extremely complex, needing thousands of tasks to be assigned across hundreds of workstations and with many precedences and zoning constraints to be taken into account. Many heuristic algorithms have been developed such as the Kilbridge and Wester method and the ranked positional weights technique. Being based on heuristics, or ‘‘rules’’ that have been tested empirically, such techniques can provide useful, although not necessarily best results [34].

Kilbridge and Wester method:

- It is a heuristic procedure which selects work elements for assignment to stations according to their position in the precedence diagram.
- elements at the end of the precedence diagram might be the first candidates to be considered just because their values are significant.

Procedure:

Construct the precedence diagram, so those nodes being work elements of the same precedence are arranged vertically in columns.

1. List the elements in order of their columns, column I at the top of the list. If an element can be in more than one column, list all columns by the element to show the transferability of the element.
2. To assign elements to workstations, start with the column I elements. Continue the assignment procedure in order of column number until the cycle time is reached [36].

2.2.3.3 Supply

The supply chain is defined as a network of facilities and distribution options that performs three tasks. One is procurement, second is manufacturing or transformation of these materials into products, and the third is distribution, which is to deliver the manufactured products to the ultimate or end customer [37].

Figure 25 shows the set of suppliers, and then there is the manufacturing or the organization produced goods are sent to customers through a channel, so it could be a distribution channel, and from there it goes to the final customer.

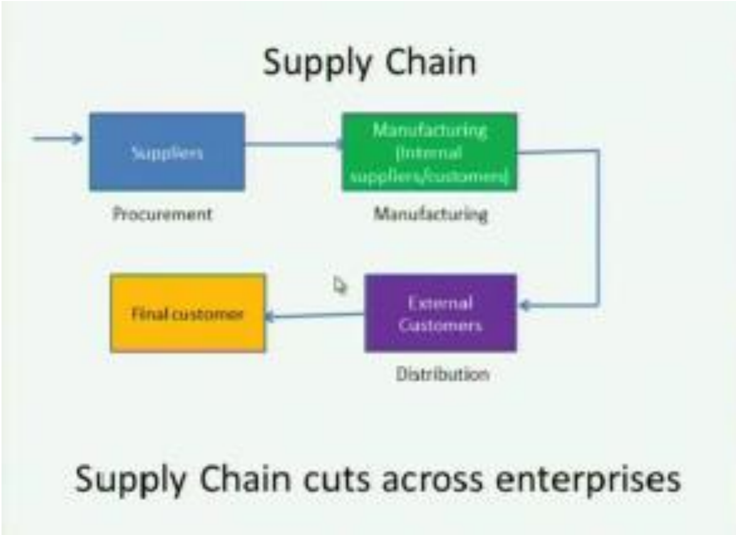


Figure 25 Represents the flow across enterprises [38].

There are four primary uses of the term ‘supply chain management’ [38]:

- First, the internal supply chain that integrates business functions involved in the flow of materials and information from inbound to outbound ends of the business.
- Secondly, the management of two-party relationships with immediate suppliers.
- Thirdly, the management of a chain of businesses including a supplier, a supplier’s suppliers, a customer and a customer’s customer, and so on.
- Fourthly, the management of a network of interconnected businesses involved in the ultimate provision of product and service packages needed by end customers.

Performance in supply chain management

Network performance

Easton [39] investigated performance differences between single-sourcing and multiple-sourcing networks. They proposed that single-sourcing networks would be more rigid and stronger as there would be dense flows of exchanges within them. It would also be easier to keep confidentiality in single sourcing. However, the advantages of multi-source or extensive networks included an ability to adapt to changes in the environment through switching and a broader base to generate innovation from advocated multiple sourcing as an essential strategy for firms who needed to reduce uncertainty in purchasing.

Chain performance

Logistics research into chain performance has focused primarily on improving speed and cost performance. Improvements in speed and cost may relate to the physical supply chain, through which materials are converted, and goods flow to end customers, or to the process chain of orders and demand transmission [40].

Relationship performance

Recent purchasing literature emphasizes the increasing importance of measuring and monitoring performance within relationships because of the increased dependency between the parties. A performance measurement system implemented by the purchasing party can enhance the buy-sell relationship. However, most performance measurement systems in use do not do this for three main reasons. First, they incorporate mostly hard, objective measures which may not be proper for measuring softer features of capability and performance. Secondly, the measurement systems are usually designed by the purchasing organization for the purchasing organization, rather than for the relationship as a quasi-organization [41].

2.3 Lean concepts and tools

Lean is a management philosophy that focuses on reconfiguring organizational processes to continually reduce and eliminate waste over time, thereby contributing to efficiency and value creation for the customer [42].

The concept of lean is the Toyota way, promoted by Toyota which helps in improving the flow of a process in a system is by dropping any uneven workflow throughout the system. Tools namely pull system by “Kanban” and production smoothing or “heijunka” are used for improving the flow in a system.

Womack and Jones [43] stated lean is a management philosophy that focuses on reconfiguring organizational processes to continually reduce and cut waste over time, thereby contributing to efficiency and value creation for the customer. To this end, Lean applies specialist analytical tools and techniques.

The concept helps in reducing waste (Muda) in any organization without affecting its products or services, which also includes the waste occurred due to overburden (muri) and uneven workload (Mura) scenarios, which are considered as significant causes of creating losses. Several tools and practices have been developed to achieve lean.

Figure 26 presents the classification of the tools as suggested by Salonitis and Tsinopoulos [44].

Figure 26 Lean manufacturing tools and practices [44].

The use of lean will allow any organization to achieve continuous and valuable propositions for their key stakeholders. A lean manufacturing initiative is focused on cost reduction and increases in turnover by systematically and continuously cutting all non-value-added activities [45].

Benefits of lean

As been said by many authors the benefits of lean can be grouped and represent five improvement dimensions: waste elimination, continuous improvement, continuous flow, and pull-driven systems, multifunctional teams, and information systems. The main benefits are related to the reduction of different type of resources, reduced delivery time, increased productivity, higher quality, faster problem solving and decision making, and higher customer satisfaction [46].

Through lean, manufacturing can be achieved by using less human effort in the factory, less space, less financial resources and less material for producing the same product [47].

2.3.1 Concept of waste

The concepts of waste are central to the Lean method that has been adapted from its manufacturing origins and applied successfully to the context in several organizations.

Howell defines waste as the difference in productivity when benchmarked against the performance criteria for a production system; failure to meet the unique requirements of a client considered waste [48].

Waste also defined as "Anything that does not add value to the customer is a waste" Waste adds to time and cost. This definition captures the thinking behind operations management most effectively because it takes into consideration not just the material wastes, but also other resources like time and labor to which we can assign some form of value [49].

Waste can be in the form of additional output, input, or processing. It can be in the form of materials, stocks, equipment, facilities, manhours, utilities, documents, expenses, motion, and other activities that do not add value [50].

Muda, Muri, Mura are three different types of wastes.

Muda

Muda means waste or uselessness. This type of waste characterized by using time, money and resources, while not adding any value to the customer. The goal of finding Muda is to recognize which steps are necessary for the process and which need to be reduced or eliminated [51].

- Type I Muda: Non-value-added tasks which seem to be essential. Business conditions need to be changed to cut this type of waste.
- Type II Muda: Non-value-added tasks which can be eliminated at once.

Taiichi Ohno, the author of Toyota Production System, devised seven manufacturing wastes: Overproduction, Inventory, Over-processing, Correction, Waiting, Conveyance, and Motion [52].

Muri

Muri means overburden or unreasonableness (waste of overloading equipment, facility or people resources beyond its ability).

Mura

Mura means variation or unevenness. It refers to waste of unevenness in production volume. It may take two different forms: variation in production scheduling, uneven production workload, and pace of work.

2.3.2 POKE-YOKE

In 1961 Shigeo Shingo introduced Poka-Yoke method when he is one of the engineers at Toyota Motor Corporation. This method, in other words, is to prevent defects and errors originating in the mistake [53].

The basis for poke yoke is that defects occur because of worker errors. Although poke yokes may be used for mistake-proofing any process, poke yokes are usually targeted to repetitive tasks where the potential for human error is more likely [54]. Poka-Yoke design can dramatically decrease the risk of producing defectives again [55]. The aim of

Poka-Yoke method is to eliminate or minimize human errors in manufacturing processes and management because of mental and physical human imperfections [53].

D.Tommelein [56] after performing mistake-proofing in an AEC (Architecture Engineering construction) industry stated that mistake-proofing could be practiced within a specialty (e.g., plumbing, electrical, or mechanical work), it can be practiced by designers, manufacturers or fabricators to benefit a product as it is being constructed or throughout its lifecycle performance, or it can be practiced by designers to benefit a system.

Poke-yoke inspection methods

Successive, self, and source inspection can be achieved using poke yoke methods. Poke-yoke achieves 100 percent inspection through mechanical or physical control [57].

Regulatory functions of poke yoke

There are two ways where poke yoke can be used to correct mistakes.

- Control type
  The control poke-yoke is the most robust corrective device because it shuts down the process until the poor condition has been corrected [57].
- Warning type
  The warning poke-yoke allows defective processing to continue if workers do not respond to the warning [57].

Figure 27 shows the two types poke yoke methods.

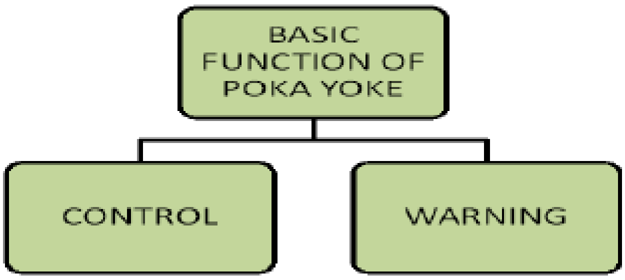


Figure 27 Function of Poke-Yoke [58].

The decision to implement a poke-yoke must be made based on a cost-benefit analysis. The control poke-yoke is the more effective in most cases [57].

There are three types of control poke-yoke.

- The contact method finds defects by slight changes in product shape or dimension are sometimes introduced deliberately to make defects easier to find, color differences.
- The fixed value method decides whether a given number of movements is made.

- The motion step method decides whether the established steps or motions of a procedure are followed [57].

The Poka-Yoke is a technique for avoiding human error at work. A defect exists in either of two states; the defect either has already occurred, calling for defect detection, or is about to occur, calling for defect prediction [59].

Step by step process in applying poka-yoke:

- Find the operation or process
- Analyze and understand the ways in which a process can fail.
- Decide the right Poka-yoke approach, such as using a,
    - Control Type: Preventing an error being made.
    - Warning Type: Highlighting that an error has been made.
- Determine whether a Contact Method, Constant Number or Counting Method, Motion-Sequence Method.
- Trial the method and see if it works.
- Train the operator, review performance and measure success [60].

2.3.3 MUDA

There are two types of waste (Muda).

Muda Type I: non-value adding, but necessary for end-customers. These are usually harder to eliminate because while classified as non-value adding, they may still be necessary. For example, while an end-customer might not view quality inspection in car assembly as value-adding, it is necessary to ensure the car meets safety standards.

Muda Type II: non-value is adding and unnecessary for end-customers. These contribute to waste, incur hidden costs, and should be eliminated.

Figure 28 shows the seven types of waste by Taiichi Ohno.

Figure 28 Types of waste [61].

Transportation

Transport is an inseparable part of the production processes which cannot be removed. However, it does not give any value to the final product, and this is why the aim is to reduce it to the lowest possible level [61].

Inventory

Inventory wastes come from the purchasing, storage of excess or excessive supplies, materials, and other resources. This waste can also be caused by overproduction as excess materials and work-in-process are accumulated. Inventory waste is often due to a lack of planning and failure to match purchases with the actual consumption or usage rate of a resource [50].

Motion

Unnecessary movements in the manufacturing environment will result in processing delays. Other unutilized talents are employee lost time, excellent skills, employee ideas, and recommendations for simplifying the process [62].

Waiting

Some common wait time is caused by processing delays, machine or system downtime, response time and signature needed for approval wait time. Delay usually caused by the loading and unloading the workpiece in the machines. The operator’s time allocation is more than that of the actual processing time. This excess time allocation for the operators to do the job increases the overall wait time and delay in the process [63].

Over-production

Making more of a product that is needed results in several forms of waste, typically caused by production in large batches. The customer's needs often change over the time it takes to produce a larger batch. Over-production has been described as the subdue waste

Over-processing

Doing more to a product that is needed by the end-customer results in it taking longer and costing more to produce. They do not answer to a real need, adding more value to the service than the customers are willing to pay for. Design or build a work that presents an oversized performance if compared with real demand [64].

Defects

Whenever defects occur, extra costs are incurred by reworking the part, rescheduling production, etc. [61].

2.3.4 SMED

The SMED method was developed by Shingo (1985), who described it as a scientific approach to reduce setup times, and which can be applied to any industrial unit and to any machine.

SMED is defined as the minimum amount of time necessary to change the type of production activity taking into consideration the moment in which the last piece of a previous lot was produced to the first piece produced by the subsequent lot [65].

SMED helps to reduce machine setup times by cutting wastes and unnecessary setup processes and helps to improve current setup processes and manufacturing flexibility [66].

By focusing on the elimination of the waste associated with tool changeovers in the setup phase, SMED allows for the reduction of lot sizes and enables one to meet the fluctuation of demand. It further cuts the waste inherent to stock buildup and enhances a reduction in lead time [67].

The SMED method, in association to other Lean tools on a seat-cable assembly line at the automotive sector company, showed a reduction in setup time by at least 58.3 %, corresponding to 210 min in a week [68].

A fundamental aspect of the SMED method relates to its features of internal and external activities.

External activities

All the setup activities which do not interfere directly with the equipment, and which can be carried out without interrupting production, are designated as being external activities.

Internal activities

Those who imply a stoppage in the equipment running are described as internal activities. The correct separation of the two is what fundamentally contributes to a reduction in setup times [67].

Figure 29 shows the different phases of a SMED process.

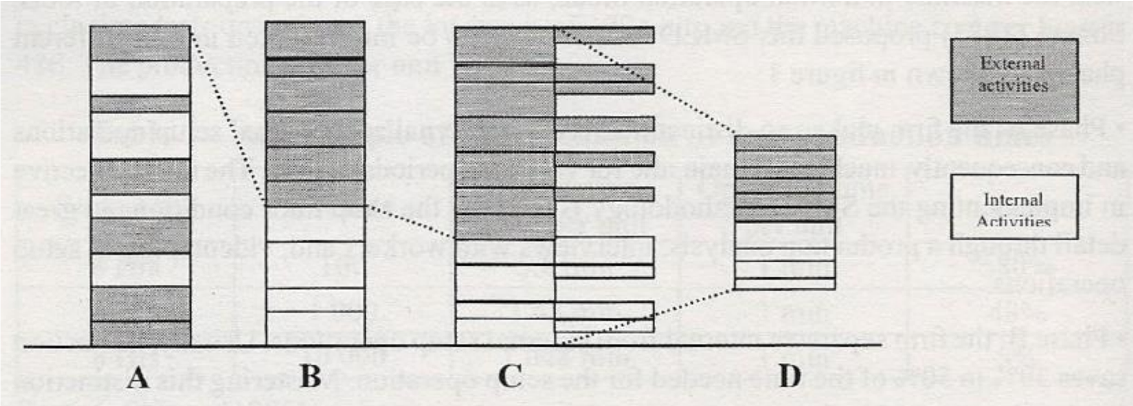


Figure 29 The phases of SMED method [69].

In sum, the SMED method consists of four phases, when aiming to reduce setup times.

- PHASE A - In this phase, there is not a clear separation between activities that must be performed while the equipment is stopped (activities that are not making parts or internal activities) and the ones that can be done while equipment is running (activities making parts or external activities). In this phase, the involvement of everyone is critical and should be specifically assured.
- PHASE B - This phase refers to the detailed characterization, organization, and separation of the operations in internal or external. Shingo (1985) considers this the most crucial phase from which the setup can be reduced from 30% to 50%.
- PHASE C - a new analysis of all operations should be done to verify the classification done in the phase B and focus effort should be directed to convert internal operations into external. The implementation of this phase should allow an improvement from 10% to 30% in the total time of internal setup of the phase B [65].
- PHASE D –the primary goal is to reduce the time of internal and external operations, through the application of the identified solutions that will allow an easy, fast and secure performance.

Benefits of Single Minute Exchange of die

- The reduction of inventory, the increase in production flexibility and the rationalization of tools is among the indirect benefits.
- The direct benefits include the reduction of setup time, the reduction of time spent with fine-tuning the machines, the reduction of errors during changeovers, the improvement of product quality and increased safety [65].

2.3.5 5S

The 5S lean tool was developed in Japan by Sakichi Toyoda, Kishiro Toyoda and Taiichi Ohno in 1960 [70]. 5S is a method of organizing the workspace, in a clean, efficient and safe manner, to achieve a productive work environment. The 5S is a starting point for any company that wants to be recognized as a responsible producer, worthy of world-class status [71].

Implementation of the five levels can reduce the amount of waste and errors, and increase productivity improve safety and quality of products or services [72].

Figure 30 shows the 5 stages of 5s as implementation steps.

Figure 30 5S method [73].

The method consists of the sequential following of five steps:

- **Seiri (Sort)**
  The workplace should only have what is needed to perform the activities. Remove all unnecessary tools and parts. Go through all tools, materials, and so forth in the plant and work area. Keep only essential items.
- **Seiton (Set in order)**
  There must be a place for everything, and everything should be in its place. Quick and visual identification of tools and areas saves time and eases processes.
- **Seiso (Shine)**
  To keep everything clean and neat One aspect of “Seiso” is to design and implement effective methods which must be integrated into the operators´ daily maintenance tasks.
- **Seiketsu (Standardize)**
  Documenting and standardizing the method, using standard procedures. Standards should be very communicative, clear and easy to understand.
- **Shinseki (Sustain)**
  The last step consists of developing a method to ensure the 5S technique is followed. It needs discipline and focus. Usually, audits are performed to assure the sustainability of the method.

The implementation of 5s in automotive cable production plant and its case study concludes that implementing and maintaining 5S method and standards in the company led to improved performances increase of the productivity of the organization, the safety at workplace and the product quality has been increased [73].

5S bring several benefits to a company, being the most relevant one the decrease in a waste of time and space. According to Hirano, the rewards of applying 5S are extended to quality, security, and hygiene [74].

2.4 Continuum improvement tools

Continuous improvement, or Kaizen, is a method for finding opportunities for streamlining work and reducing waste. The practice was formalized by the popularity of Lean / Agile / Kaizen in manufacturing and business, and it is now being used by thousands of companies all over the world to find savings opportunities. Many of these ideologies can be combined for excellent results. For example, Kaizen and Kanban can go hand-in-hand to facilitate continuous improvement.

2.4.1 PDCA

Deming introduced PDCA to Japanese enterprises in 1950. according to which quality improvements take place through four significant steps: Plan-Do-Check-Act. Since then Japan has become the world leader in quality management [75]. PDCA is a successive cycle which starts off small to test potential effects on processes, but then gradually leads to more substantial and more targeted change [76]. It consists of a logical sequence of four repetitive steps for continuous improvement and learning. These all four steps are repeated over and over as part of a never-ending cycle for improvement [77]. Figure 31 shows the process of the PDCA cycle in a clockwise direction

Figure 31 PDCA Cycle [77].

According to Gorenflo and Moran [78] [79], the phases of PDCA can be understood as follows,

- Plan: In this phase, opportunities for improvement are found and prioritized; the current situation of the process is investigated through consistent data; the causes of the problem are determined, and possible actions to mitigate the issues are chalked out.
- Do: The purpose of this step is to implement the action plan; select and document data voluntarily; and note the unexpected events, lessons learned, and knowledge gained.
- Check: At this point, the results of the actions are analyzed. The new situation is compared to the old, verifying if there were improvements and whether aims were met. For this, various graph support tools are used.
- Action: At this stage, the team involved develops methods that will standardize the improvement (if the result has been reached); repeats the test to collect new data and re-evaluate the intervention (if the collected data is insufficient, or circumstances have changed); or abandon the project and make another beginning from stage 1 (if the actions taken have not generated useful improvements).

The application of PDCA has seen various improvements in different scenarios where they were performed. According to PDCA Processes can be improved with changes in workplace layout, material handling system, workplace arrangement, and Standardization of operations [80].

The PDCA cycle ensures two types of corrective action – temporary and permanent. The short action is aimed at practically tackling and fixing the problem. The permanent corrective action consists of investigation and cutting the root causes and thus targets the sustainability of the improved process [81].

2.4.2 TFM

TFM is then defined as an integrated concept to increase Process Flow and Effectiveness (Pull) across the Totality of a Supply Chain. The targets are the reduction of the total lead time in the SC. Reducing lead time also drops Muda of waiting and really means creating a material flow [82].

Primarily, it is necessary to create an internal pull flow in maximum operational efficiency and free of non-value added activities (NVAA), then consider the extension to the valley (the delivery side, i.e., customers) and upstream (the source side, i.e., the suppliers).

Figure 32 shows the TFM model having the internal pull flow having the suppliers, customers as for source and destination respectively.

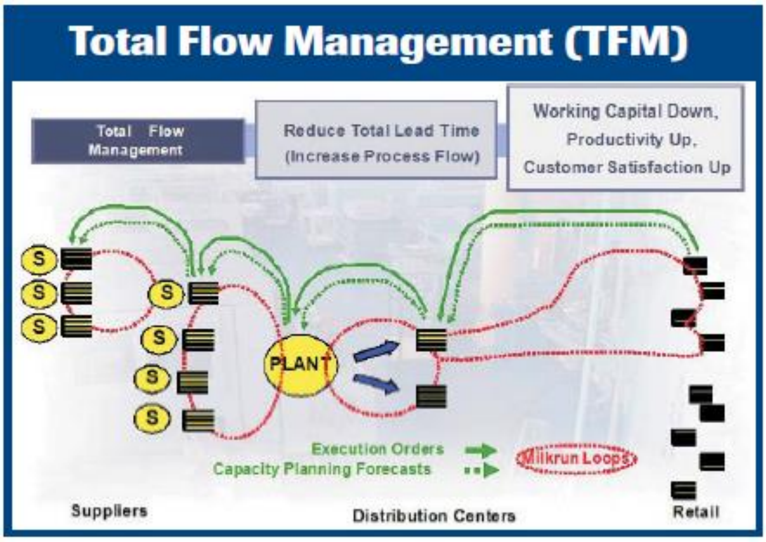


Figure 32 TFM model [83].

The flow of materials can be considered as a repeated sequence of four types of transaction, namely transport, inspection, waiting and transformation, the only value-added activities. The primary objective is the reduction of total lead time, as regular coverage of stocks, eliminating Muda process, creating benefits in terms of cost reduction and working capital, increased productivity and quality in order to achieve a higher level of service provided to customers and to improve, therefore, the satisfaction [84].

Figure 33 shows the TFM pillars and the strategies involved in each pillar.

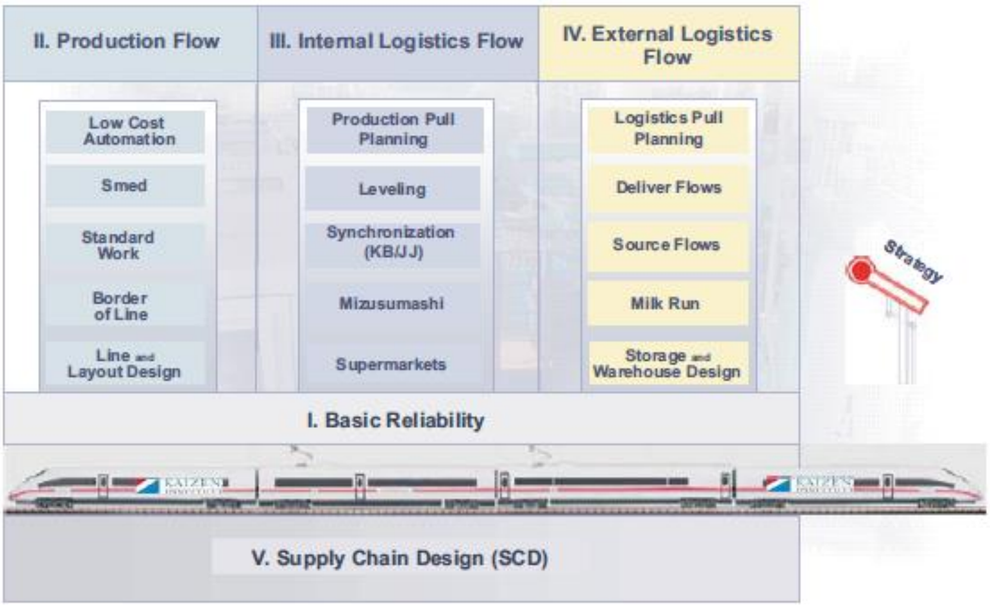


Figure 33 Total Flow Management Pillars [83].

TFM is a model that can trigger a breakthrough in the performance of any Supply Chain, and that embodies the power of a complete lean transformation [83].

The flow of information and materials found through the analysis of logistic loop can be grouped into three pillars of TFM Figure 33.

- Production Flow;
- Internal coordination flow;
- External coordination flow.

In a Total Flow Management optics, each of these flows must be analyzed and perfected by applying the principles of Lean and Kaizen tools.

The first step is to improve the production flow, which ranks as aims the implementation of the one-piece flow, increased flexibility by adjusting the setup and an increase in operational efficiency and supply.

The improvement actions are divided into these categories:

Redesign of the layout and lines in one-piece optical flow; redesign of the perimeter of the line for the efficiency of supply; definition of standard work for operational efficiency; SMED technique for flexibility in setup, low-cost automation to reduce the walls.

The second step is the optimization of internal logistics flows, including all the movements of small containers inside the plant but also the related information flows.

The improvement actions are divided into these categories:

- A system to simplify and streamline internal transport of the material to the point of use; synchronization as coordination between supply and production leveling productivity of the lines and equipment in relation to the takt time, pull production planning by the actual customer orders.

Finally, the third step is the optimization of external logistics flows, i.e., the handling of materials and products, generally parceled out in pallet from the factory to customers and suppliers to the plant.

- In this case, the categories of intervention are: redesign of the stores and warehouses; creation of the milk run, i.e. an external flow of transport; physical flows in (inbound) and outgoing (outbound) through small containers and pallets; planning pull the logistics to handle the material withdrawals according to the royal orders of consumers.

2.4.3 OEE

Overall Equipment Effectiveness (OEE) is a crucial measurement of efficiency in manufacturing processes (at the machine, manufacturing cell or assembly line levels)

[9]. It is defined as the ratio of producing goods of approved quality to the scheduled production time (loading time) [85]. The OEE has been applied as a measurement tool and decision-making aid for improving productivity by improving equipment [86]. In general, OEE is decided according to each machine used in a production process to identify its availability, quality and performance contributions and to observe the possible relationships between the different parameters of influence.

Equation 2 Represents the formulas involved in calculating OEE.

Equation 2 formulations in calculating OEE

$$Availability(A) := Operatime\ time/Loading\ time$$

$$Performance(P) := Net\ operating\ time/Operating\ time$$

$$Quality(Q) := valuable\ operating\ time/Net\ operating\ time$$

$$Overall\ Equipment\ Effectiveness := \ Availability * Performance * Quality$$

Figure 34 shows the six significant losses divided into the three categories such as availability, performance, and quality, where (A) availability is defined as a ratio of planned production time minus downtime (breakdowns and changeovers) over planned production time. (P) Performance efficiency is the ideal cycle time times the number of products produced over the actual runtime. The (Q) quality rate is the ratio between accepted products over several products produced.

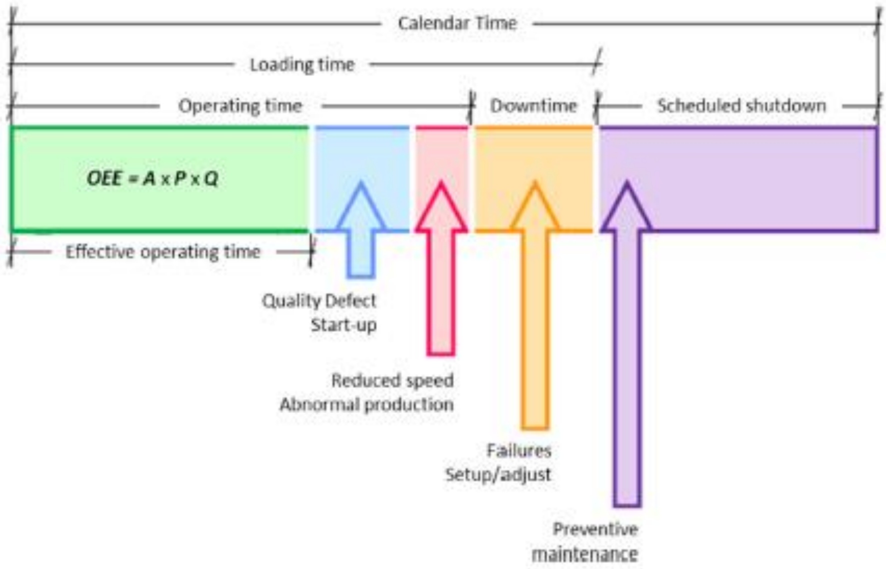


Figure 34 OEE Timeline [87].

Nakajima [86] defines the six significant losses in production as in three categories [85].

Downtime losses:

1. Equipment failures are categorized as time losses when productivity is reduced, and quantity losses caused by defective products.
2. Setup and adjustment time losses result from downtime and defective products that occur when the production of one item ends and the equipment is adjusted to meet the requirements of another item.

Speed losses:

3. Idling and minor stop losses occur when the production is interrupted by a temporary malfunction or when a machine is idling.
4. Reduced speed losses refer to the difference between equipment design speed and actual operating speed.

Quality losses:

5. Reduced yield occurs during the initial stages of production from machine startup to until stabilization.
6. Quality defects and rework are losses in quality caused by malfunctioning production equipment.

World class level of OEE is in the range of 85–92% for non-process industry [88].

THESIS DEVELOPMENT

3.1 Production lines characterization

3.2 Problem characterization

3.3 Objective

3.4 Brainstorming

3.5 SWOT analysis of possible solutions

3.6 Implementation

3 THESIS DEVELOPMENT

3.1 Production lines characterization

In this section, the characteristics of production lines where the work was performed are briefed and picturized.

3.1.1 Production line A

There are two printing machines used at this production line; they are Heidelberg Speedmaster 74-5, Heidelberg Speedmaster 52-2 having 5 and 2 printing bodies respectively, each produces products of small batches prints at 15000 sph. The machines are positioned in between the marked yellow line giving enough space for the production activity to be carried out.

Explaining the process in Heidelberg Speedmaster 74-5, production starts by receiving the order and obtaining required raw materials such as the specified size of printing paper, inks, printing plates as per specified in the job sheet.

Figure 35 shows the picture of Heidelberg Speedmaster 74-5 printing unit at Marsil.

Figure 35 Offset printing SM74-5 unit at Marsil.

The inks for the production are introduced into the inking rollers through the reservoir ducts present at heads of the printing bodies by the machine operator and are evenly spread out, and so the printing machines are made to run for the inks to reach the cylinders inside each printing bodies. The printing plates are cleaned by cleaning solutions and introduced into printing bodies in between the plate cylinder and the impression cylinder(blanket) as the machines grab the plates and set them up through the press of a button specified at each printing bodies.

Figure 36 shows the cleaning solution used for cleaning plates during the production process.

Figure 36 Plate cleaning solution

Control system

Selection of size of the printing area, the intensity of the colors to be printed, the thickness of the printing paper, size of the production is made through the control system specified for that printing unit. Figure 37 A and B shows the control system images of Speedmaster 74-5 at the printing unit.

A B

Figure 37 Control systems of SM 74-5.

The printing process begins after setup for the production is complete, and several prints for the job being printed and evaluated. The evaluation performed through a device that measures the intensity of the ink printed on the paper and the results compared to the expected level by the operator. The operator performs a few more prints by changing the intensity level on the control system and the operation repeated until the operator has a superior quality of prints for the job. This shows that the production unit is partially automated.Figure 38 A and B shows the image of measuring devices used at every production unit during preparation operations.

A

B

Figure 38 Measuring devices

Figure 39 Shows the image of goods produced by speedmaster 74-5 arraged on pallets.

Figure 39 Products produced by SM74-5.

The produced goods are then transferred to the next production unit with help of manual fork lifters, where the final goods are produced according to requirements.

Figure 40 shows the image of manual fork lifter used for transferring goods.

Figure 40 Manual fork lifter.

The speedmaster 52-2p having 2 printing bodies performs printing through two colors, using plates sizing 459x525 mm. The setup for the production is the same as the Speedmaster 74-5. The produced prints are corrected visually by comparing the prints produced to an ideal print copy and the required intensities of ink to be printed changed by changing the knob present at the heads of the printing bodies of the machine. This shows that the printing machine is partially automated.

Figure 41 shows the image of Speedmaster master 52-2 with control system along with the printing machine.

Figure 41 SM 52-2

3.1.2 Production line B

The production line B has two production units, speedmaster 52-4, and web-fed offset printing machine.

Figure 42 shows the image of Speedmaster 52-4 at the production line.

Figure 42 SM 52-4

The speedmaster 52-4 has 4 printing bodies using 4 colors for the printing process with the printing plates sizing 459x525 mm. The produced prints are corrected at the workstation which also has a control station. The setup for the production is the same as the Speedmaster 74-5. The printing machine has a control system separately with the work station.

Control system

The control system for speedmaster 52 4 is provided with the workstation, where the evaluation works are performed, and the input is fed accordingly. For example. the thickness of the sheet, dimensions of the printing area, adjustments of the margins, the flow of die and much more can be performed.

Figure 43 shows the images of the control systems for Speedmaster 52-4.

A B

Figure 43 A and B, control systems for Speedmaster 52-4

Figure 44 shows the image of goods produced by the printing machine SM 52-4.

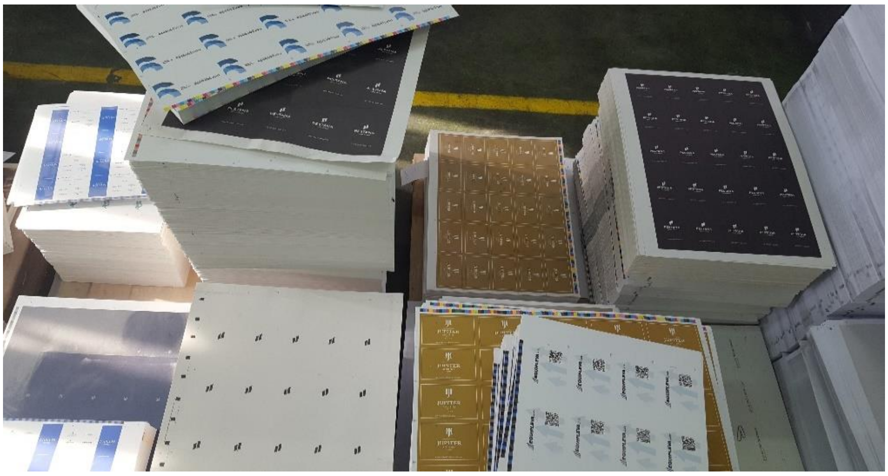


Figure 44 Goods produced at SM 52-4

The next printing unit in this line is the didde web offset printing machine with 4 printing bodies capable of printing 80m / minute. Sheets of the maximum length of 340mm to a minimum of 100mm can be printed. The machine is installed spatially along with the other 3 machines.

Figure 45 shows the picture of didde web-fed printing unit at Marsil.

Figure 45 Web-fed Printing unit

Control system

The control systems at these production units assigned along with the printing bodies. The usage of the printing bodies adjusted according to the work needs by removing one of the gears at a specific printing body that is not involved in the working of the printing machine.

Figure 46 shows the image of goods produced by didde webfed printing machine.

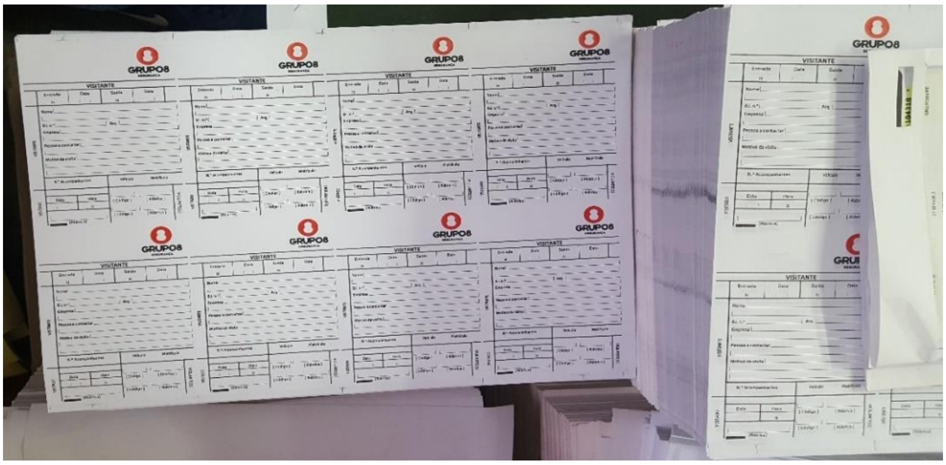


Figure 46 Products produced at the webfed unit.

3.1.3 Production line C

The Production line c has two printing machines, they are heidelberg SORM-Z and heidelberg GTO 52.

The heidelberg SORM-Z semi automated printing machine consists of 2 printing bodies uses printing plates with size 720x540 mm, capable of printing 30 million copies having printing format maximum of 720x540 mm and minimum of 280x210 mm. The machine is positioned patially along with heidelberg GTO. The control system is provided along with the machine. Each machine at the production floor is provided with fire extinguishers as safety precautions.

Figure 47 shows the image of heidelberg SORM-Z at the printing floor.

Figure 47 Heidelberg SORM-Z

The heidelberg GTO- 52 capable of printing sheets maximum of 520x360 mm to minimum of 160x80 mm with two printing bodies printing 8000 sph. The control system for GTO-52 comes along with the printing machine.

Figure 48 shows the image of heidelberg GTO-52 at the printing floor.

Figure 48 Heidelberg GTO-52

3.1.4 Production line D

The Production line D has 3 heidelberg minivera machines, cutting machines, striching machines, finishing machines as well as laminating machines at the other half of the production floor.

Three heidelberg minerva machines are used for the purpose of cutting and ceasing with maximum format of 360x260 mm to a minimum format of 80x50 mm operating at a speed of 3000 sph.Figure 49 shows the 3 heideberg minerva cut and cease machines at the printing floor.

Figure 49 Heidelberg Minerva

The cutting machines each are with specific specification but all does the same work of cutting required printing sheets for production,cutting works required by the printed products.

Table 2 Shows the specifications of three cutting machines present at the floor.

Table 2 cutting machine specification

Model	Maximum format	Minimum format
Polar-76	760x760 mm	30x760 mm
Polar 78	780x780mm	30x780mm
Polar-92	920x920mm	30x920mm

Figure 50 shows the picture of polar 92 cutting machine.

Figure 50 Cutting machine polar 92

There are two finishing machines at the floor they heidelberg STAHL Ti-52 and Double 600i

Heidelberg STAHL Ti-52 performs actions such as creasing, perforating and cutting jobs in the folder. It increases fold quality and allows for a multi-up processing having processing speed of 200 m/minute and 10 m/minute as maximum and minimum speed respectively. This machine is used for creating magazines which includes all the above mentioned actions.

Figure 51 shows the image of heidelberg STAHL Ti-52 finishing machine.

Figure 51 Heidelberg STAHL Ti-52

The double 600i finishing maching with maximum format of 660x330 mm to a minimum of 120x180mm performing at a speed of 3750 sph performs the same actions as of heidelberg STAHL Ti.

Figure 52 shows the image of double 600i finishing machine at the printing floor.

Figure 52 Double 600i.

3.2 Problem characterization

The problems in the company were segmented as follows: -

1. Missing of machine tools in the printing floor/ creating a tool room. The issue is when a specific tool is taken for a machining purpose; the tool is left somewhere, unnoticed after its use causing difficulties (waste of time) when the same tool is needed by another worker on the floor, no enlistments of the tools neither proper maintenance of the tool room nor tool chart.

Figure 53 shows the tool room used, left with residues and the tool board being empty.

Figure 53 Pegboard with the missing tools.

2. Improper usage of the ink's in the paint room; the issue found to be is that inks are prepared and stored in tins; these ink tins are labeled in markers and left

open once after their use. These ink tins do not have any organized setup such that the tins of different Pantone numbers get mixed up resulting in the unnoticed behavior of the operator, lead to drying of paints and ending as waste.

3. The company has printing machines using printing plates of four varied sizes 400 x 510 mm, 450 x 628 mm, 605 x 745 mm, 615 x 724 mm. The printing plates which are made for the printing works are used, and they are kept organized on the floor according to their client once after the job is completed. This has been followed for a long time and ended up in stacking up vast volumes of printing plates together, which resulted in consuming a lot of time while retrieving those when there is a reorder of a job made by the client. The time taken for a worker to retrieve a plate for a specific job was found to be 15-30 mins and up to 60 mins at times. When a specific printing plate was not to be found, set of printing plates for the concerned job is made and provided to workers resulting in added wastage of the production time.

Figure 54 shows the image of plates arranged on the floor according to their clients.

Figure 54 Printing plates arranged on the floor according to their clients.

3.3 Objective

The aim of this thesis is to improve the conditions of the above-stated problems at Marsil with the help of lean tools and continuous improvement tools by,

- Creating a tool room for the machinery works to take place and to create a tool chart for organizing tools.
- Creating a system for organizing the ink tins in the paint room.

- Implementing a system for the printing plates to be organized and quick retrieval of the plates from the system for the printing jobs.

3.4 Brainstorming

Brainstorming is a process of generating ideas and solutions through fast thinking and group discussion. In this section, brainstorming is made on the problems said by the management and possible solutions and ideas were reached.

3.4.1 Objective A

Brainstorming sessions were made on the creating a tool room consisting of a tool-chart. The problem seen was the tool room stuffed with many printed goods, machines and with residues of works performed in the room.

Figure 55 shows various causes that led to the missing of tools on the production floor as well as unmanaged tool room.

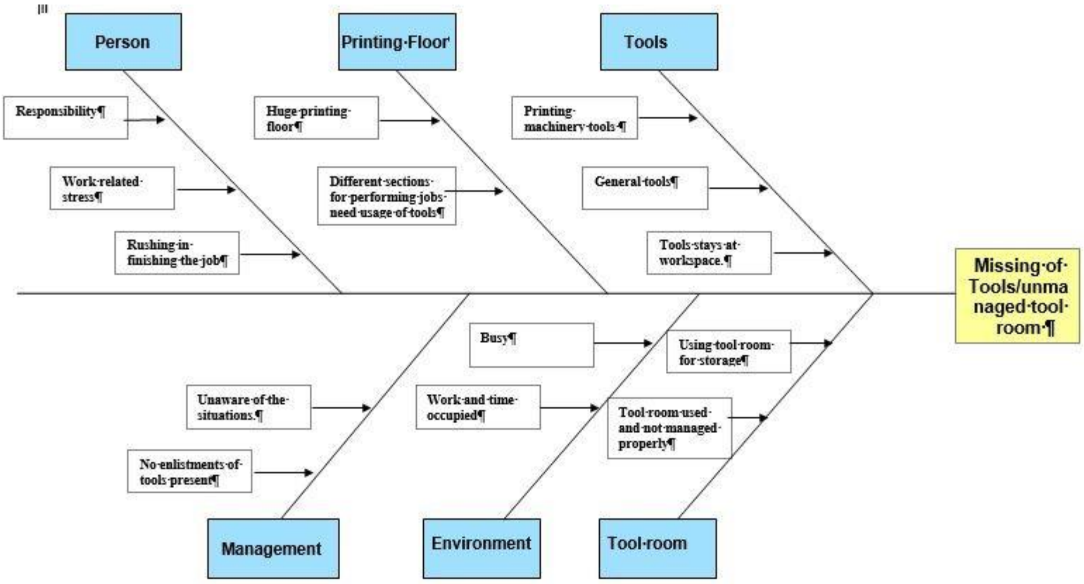


Figure 55 Cause and Effect diagram on missing tools and unmanaged paint room.

Researches were done on the process of creating a system that keeps tracks on the usage of tools and controlling the flow of resources from the pegboard. Kanban pull system is studied where the goal of such a system is to replace what has been consumed at that time when resources are needed or asked. Here in this system color cards (Kanban cards) of different colors will be used to show the availability of the resource in the clipboard Layout of the working floor made by showing the production lines and the working areas as blocks in different colors. The color of each production line shows the color card or the Kanban card assigned to it.

In preparing setting up the system the documentation of the work which includes the checklists of the available tools and machinery should be made and checked the working of the system is then explained to all the operators in the printing floor, and the system should be studied regularly.

3.4.2 Objective B

The issue said to be the lack in the organization of ink tins in the paint room Inks are prepared according to the production needs, i.e., when the job sheet reaches the respective production unit on the printing floor, press operator decides to make the required ink for the production use for that specific job. The ink is prepared with the help of the Pantone matching system, which shows the required quantity of colors to be mixed in creating that ink which is then stored in tins.

After the production process in preparing the prints of a job is completed, tin consisting the remaining quantity of ink is labeled with Pantone number by markers as indicators and are stored in the paint room. These paint tins are left unnoticed due lack of proper arrangement, which is left to dry and is not used again, to solve this issue, discussions were made, and an idea was proposed in arranging the ink tins according to Pantone series.

Figure 56 shows the various causes; their part leads to unorganized ink tins and drying of paints.

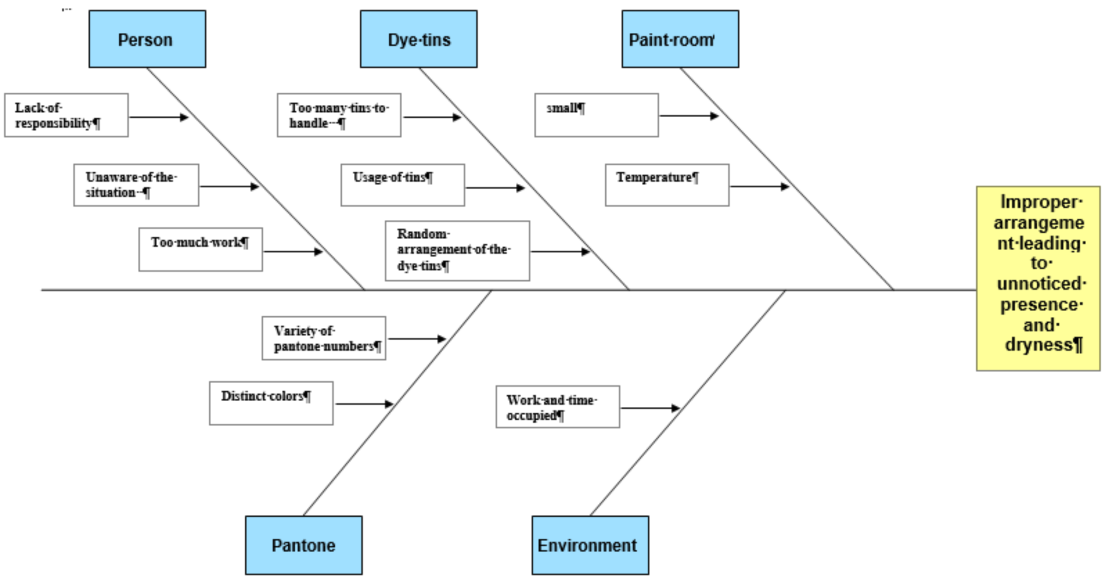


Figure 56 Cause and effect diagram on unorganized ink tins.

Discussions were made, and ideas were explored on areas of warehouse codification and, arranging the ink tins in a better way for easy accessibility and labeling of the ink tins.

3.4.3 Objective C

The problems told by the management before working on the printing plates were, the operators spend much longer time in searching for the printing plates when there is a job that needs printing plates produced before as because many client's requests reorder and they do not have a system for organizing the printing plates.

The first scenario was printing plates kept on the floor according to the clients with support to the wall. Since the company provide service to many clients there exist many printing plates associated to many job numbers. The workers receive the order sheet have the order made by the client which consists of the order number, size of the plate, number of plates to be used for the specific job and a preview copy of the same job that was done long before. The order sheet also includes the work of the previous jobs carried on the same work with few variations. So, this ensures that there are many job sheets of different order numbers of the same work. The management also told that, if there are changes in a job that has been done before, the plate manufacturer prepares the new plates for job updates the order sheet of the job. This order sheet and the plate along with plates is received by the operator, and the job is carried out. The plates are arranged along with other plates that were made for the same client. The operators in the printing floor said that it might take them 30-45 mins or even more when they are trying to retrieve plates for reorders.

Figure 57 shows the cause and effect diagram on setup made by the organization.

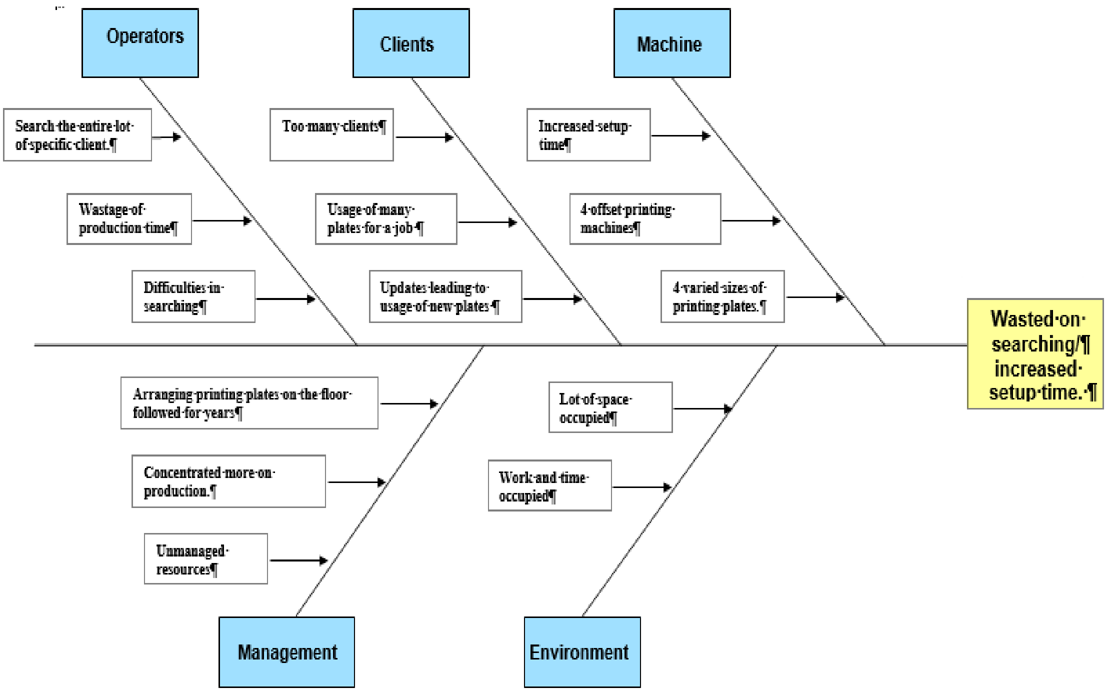


Figure 57 Cause and effect diagram on printing plate setup made by management.

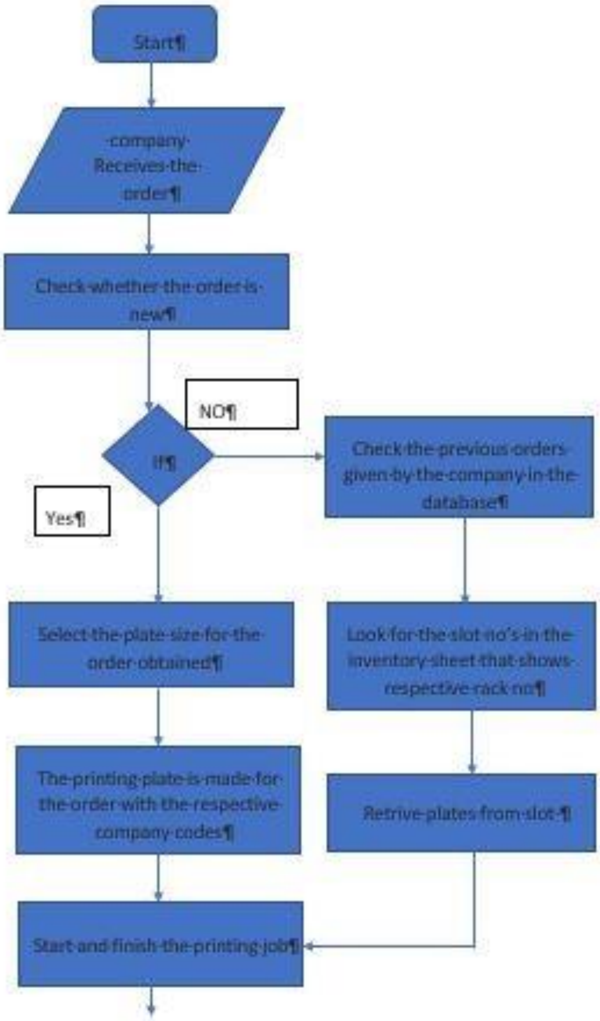
Discussions made with operators and the management about a system for the organization and retrieving the plates in a short span of time Researches made onto check types of storing systems available in the market for organizing the plates. Results were found with systems capable of hanging the plates to it with the help of hooks with covers for the plates and found to be expensive. Hence, disagreed by the management.

In minimize the usage of production time in searching for the printing plates for an order, the organization suggested arranging the printed plates inside the cardboard boxes(boxes of the printing plates when bought newly). The method proposed to be simple that involves arranging the plates inside the boxes and specifying a number on the boxes that will be written in the order sheet that the operators receive. The capacity of each box found to be 60 and arranging 60 plates in those will be seeming to be congested and will be difficult for the operators in retrieving the necessary plates needed for a job and will consume a lot of space and requires work to be done while arranging them in boxes.

The printing plates have information such as the company's name, model number, job number, sheet number, date of manufacturing the plates. So, all these need to be considered while designing the system for the organization of the printing plates.

The company had resources in implementing three racks with the length of 240 cm. The idea was to divide the rack of length 240 cm into 54 slots with separators between each slot. The thickness of the separators is 0.4 cm and the width of each slot is 4cm a rough estimation of 35-40 plates each of 450 x 628 mm shall be placed into those slots, and a total of 2160 plates can organize into these 54 slots divided from 240 cm length rack. Identification of the plates can be made by code which has a combination of an alphabet and number. The codification will be made by assigning an alphabet to each row and a number to each slot. Here the alphabets A, B, C assigned to the three racks and the numbers from 1- 54 assigned to the slots. Hence the plates can be arranged into the slots which give the slot locations as A1, A2, A3, $A_n$etc.

Figure 58 below-mentioned flowchart shows the flow of work from receiving the order, manufacturing the printing plates, operators receiving the plates for production, management decision on saving the plates or throwing them away as thrash.


Start¶
company Receives the order¶
Check whether the order is new¶
NO¶
If¶
Yes¶
Check the previous orders given by the company in the database¶
Select the plate size for the order obtained¶
Look for the slot no's in the inventory sheet that shows respective rack no¶
The printing plate is made for the order with the respective company codes¶
Retrive plates from slot ¶
Start and finish the printing job¶

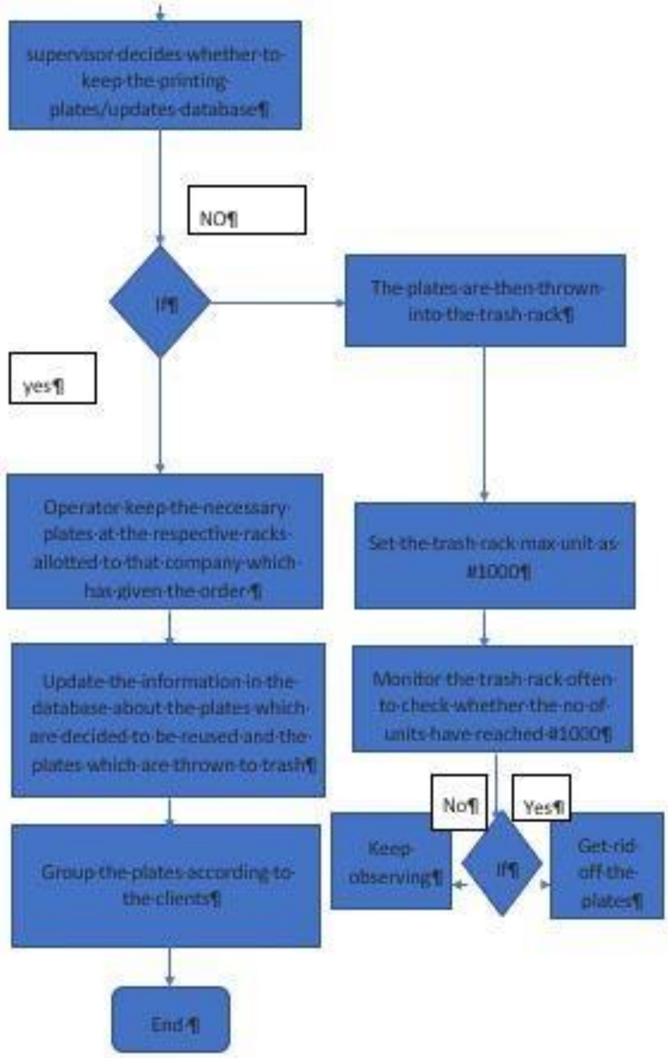


Figure 58 Flow chart.

3.5 SWOT analysis of possible solutions

In this section, SWOT analysis is made on the ideas proposed for the aim to understand the strength, weakness, opportunities, and threats involved in implementing the ideas.

3.5.1 Objective A SWOT analysis

The SWOT analysis made on the idea to be implemented in creating a tool chart, distribution of tools to all the units at the printing floor and in the maintenance of the tool room.

Figure 59 shows the SWOT analysis of Strength, weakness, opportunity, and threats involved in implementing the tool 5s and in creating the tool chart.

INTERNAL FACTORS	
STRENGTHS (+)	WEAKNESSES (–)
• Misplacing of tools is avoided. • Easy to understand. • All tools at one place. • Use of color identifiers.	• Replacing the tools. • Use of cards. • Reliability of the system.
EXTERNAL FACTORS	
THREATS (–)	OPPORTUNITIES (+)
• Loss of tools	• inspection. • Cleanliness of the tool room. • Implementation of lean. • Identifying positional usage of the tool.

Figure 59 SWOT analysis on objective A.

3.5.2 Objective B SWOT analysis

The SWOT analysis performed on organizing the ink tins on shelves shows various strengths, weakness, opportunities, threats gathered, giving enough support in implementing the system.

Figure 60 shows the strength, weakness, opportunity, and threat involved in creating a system for organized ink tins.

INTERNAL FACTORS	
STRENGTHS (+)	WEAKNESSES (–)
• Organized tins; • Usage of shelves; • Easy to understand.	• Fully occupied shelves; • Reliability of the system; • Use of shelves for specified pantones. • Less space at paint room.
EXTERNAL FACTORS	
THREATS (–)	OPPORTUNITIES (+)
• Mixing of dye tins; • The possibility of getting the system congested.	• Inspection. • Categorizing the dye tins; • Guidelines and instructions; • Use of labels.

Figure 60 SWOT on objective B.

3.5.3 Objective C SWOT analysis

The SWOT analysis structured on the idea of creating a system in organizing the printing plates into it. The positive effects in using the continuous improvement tool in implementing the system and gathering of data about the plates and configuring them in working together to work efficiently.

Figure 61 shows the Strength, weakness, opportunity, and threats involved in creating two systems for organizing the plates.

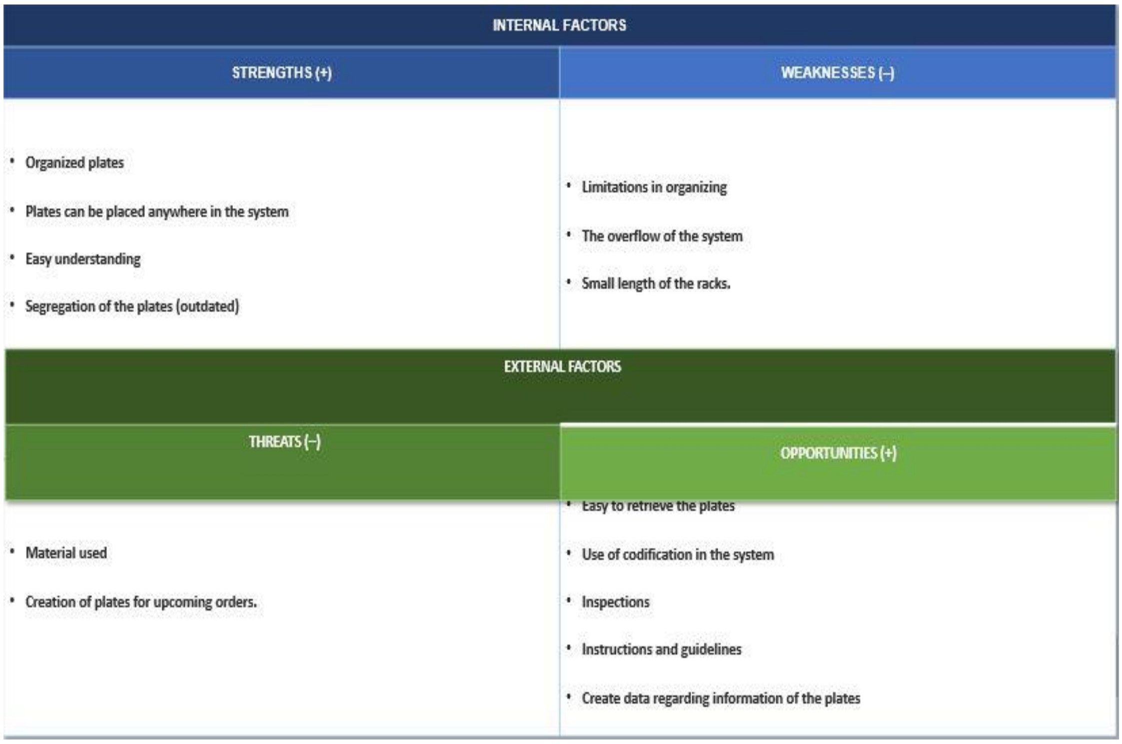


Figure 61 SWOT on objective C.

3.6 Implementation

This section shows the practice of the continuous improvement and other lean tools on each of the objectives and their procedures in implementing the steps and achieving the results.

3.6.1 Implementation of 5S

Implementation steps

1. The tool room was initially seen filled with printed goods and with other finished materials. These printed materials were considered waste by the company since they were outdated and did not add any value. Hence they were cleared from the tool room.
2. Tools, except machinery tools (tools that came along with the machine), were collected from every production line and an inventory list of the available tools in the printing floor was made. Tools that were needed or requested by any operator were bought, so the missing tools were covered.

Figure 62 shows the image of tools collected as being a step in implementing 5s.

Figure 62 Collected tools.

3. Tools are left to hang on the pegboard with the help of hooks. Organization of the tools were done according to increase in the order of their sizes for each category of tools and were arranged in such a way that the entire pegboard is filled with the available tools.
4. The entire tool room was cleaned, and for the distribution of tools to the machines at the printing floor, Kanban system was studied, and the use of Kanban cards to effectively implement the pull system.
5. The entire layout of the printing floor with production lines was designed. During this process, production lines in the floor have been segmented and were assigned to a specific color in the layout design. The Kanban cards of colors Red, green, yellow, orange, dark blue, brown and purple were made These Kanban cards represents the segmented production units designed in the layout.

Figure 63 kanban cards of different colors created to replace the tool spot in absence of tools from the peg board.

Figure 63 Kanban cards.

Figure 64 shows the simple layout of the printing floor with the position of production units defined in colors, to show the Kanban cards assigned to those units.

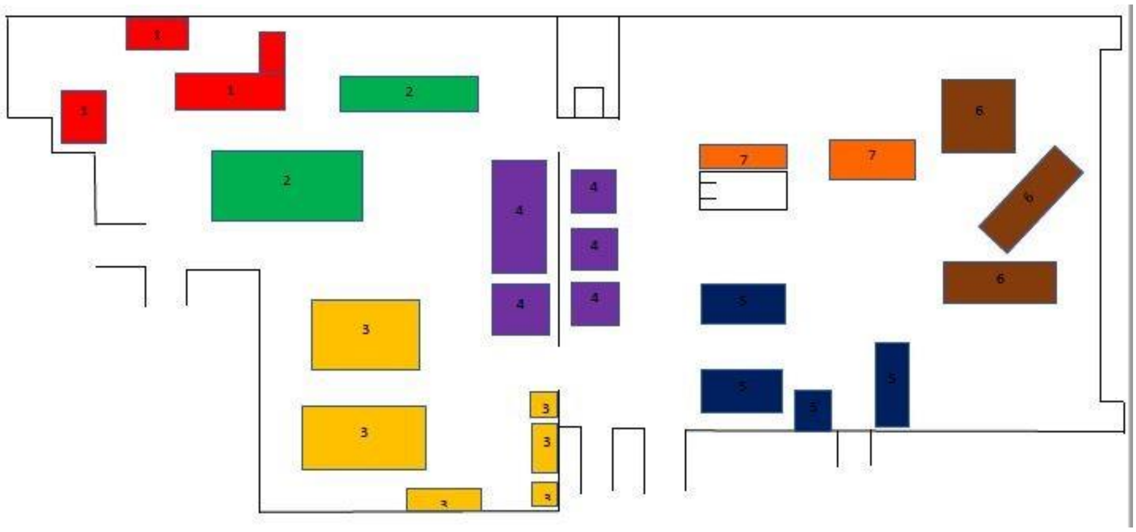


Figure 64 Simple floor layout is highlighting the production units in colors.

6. The designed printing floor layout along with the Kanban cards left to hang alongside with the pegboard to visually help the operator to understand the system.

Working of the system

The system works with the help of the color cards.

- When an operator needs a tool for a specific work to be performed, the operator should check the layout designed which shows the production line and the associated color.
- The next step is pick up a color card of the production line and place it in the place where the tools are rested in the pegboard Placing the color card in the tool place shows that the tool is in use.
- The tool that is taken for performing work is returned by dropping down the color card from the pegboard and replacing it with the tool that is taken.

Standardized procedures have been written on the working of the system, usage of the 5s method and were explained to the workers using the Kanban card system implemented. This also includes the documentation work on the inventory list of all the available tools on the clipboards and their quantities. This stage of 5s educates everyone on the printing floor about the implemented method and to increase awareness about the maintenance of the tool room and about the usage of the tools.

Figure 65 shows the inventory list taken while performing the tool 5s.

MARSIL Artes Graficas Lda - Lista de ferramentas					
S.No	Ferramenta	Unidades	S.No	Ferramenta	Unidades
			21	Jogo chaves caixa 1/4 29 pcs	1 Caixa
1	Conjunto Ferramenta		22	Jogo 8 chaves mista	8
(i)	Chave de fenda de cabeça cruzada		23	Jogo 9 chaves allen	2 Jogo
	1x75 mm	1	24	Martelo	1
	2x38 mm	1	25	Serra tico-tico 400W	1
	1x100 mm	2	26	Hacksaw lâmina	1
	2x100 mm	2			
	3x150 mm	2			
(ii)	*Fresta chave de fenda*				
	6.5x38 mm	1			
	5.5x75 mm	1			
	4x100	1			
	5.5x100	1			
	6.5x100 mm	1			
	8x150 mm	2			
(iii)	*Chaves de fenda de precisão*				
	SL 2 mm	1			
	SL 2.5 mm	1			
	SL 3 mm	1			
	PH 0	1			
	PH 00	1			
	T6	1			
	T8	1			
	T 10	1			
(iv)	20 Bits - 25 mm (Labled in the container)	1 Jogo			
2	Bit comprimento do adaptor	1			
3	Europa oriental (20 pcs)	1 Caixa			
4	Chaves de fenda de precisao set (T15-T10-T9-T8-T7-T6-T5-#1-#0-3mm-2.4mm-2.0mm)	1 Jogo			
5	KRONE LSA-PLUS	1			
6	Mandril da chave de perfuração	2			
7	Mini tocha	1			
8	lâmina cortante	1			
9	fita métrica - 5M	1			
10	Kit de solda	1			
11	L - escale	1			
12	lâmina de serra	1			
13	Cume da serra (hacksaw)	1			
14	Extensor set (5 pcs)	1			
15	Chave inglesa fechada 10 - 11	1			
16	Chave inglesa mistar - 13	1			
17	Chave inglesa aberta 20-22	1			
18	encadernador	1			
19	Armadura de carpinteiro	1			
20	Chave tubular hexagonal	5			

Figure 65 inventory list of tools.

7. Once after implementation and explaining the working of system to all operators, the tool room was inspected for a period. During this period, the entire system was evaluated by using a checklist of available tools and tools on the pegboard. It was also seen that the tool room is cleaned regularly and the usage of the cards by operators while selecting a tool and returning it, was followed.

Figure 66 and Figure 67 shows the images of the tool room before and after implementation of the 5s tool.

Figure 66 Toolroom before implementation.

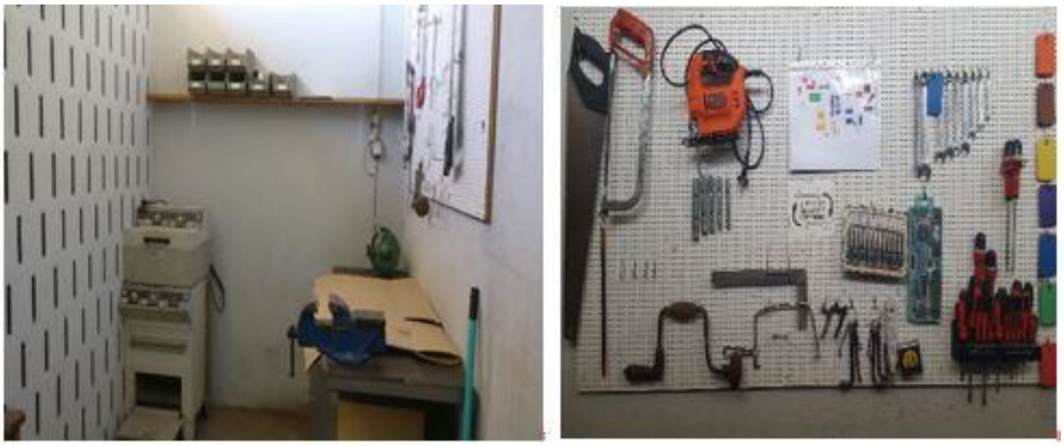


Figure 67 Toolroom after implementation.

3.6.2 Implementation of 5S in paint room

Implementation steps

1. Initially, ink tins were checked to confirm that the inks are in good condition or whether they have dried. By doing so, the tins with proper ink, separated from the bad ones and were gathered in a separate place in the paint room.
2. Space is created after moving the tins and resources for building the racks in the paint room were bought by the management. 2 columns each with 5 racks constructed with the help of nuts and bolts.
3. Labels for showing information such as the Pantone number and for showing the odd and even sides of the rack were designed and printed. Each column has five racks where the left side of the first rack, label mentioned as "series starting with 1 -ending with an odd number" and on the right side of the rack "series starting with 1 and ending with the even number" were struck. Similarly, for Pantone

series 2 till Pantone series 10 labels are struck on both sides of the rack showing the odd and even sides of the series.

Figure 68 shows label struck on shelf as indicators for organizing the ink tins.

Figure 68 Labels as indicators.

4. After indicators were struck on the racks, labels for showing Pantone number were struck on the ink tins, and the Pantone number is written on them. The Pantone number is written to show the ink associated with it, and ink tins were organized according to indicators on the racks. For example, consider a ink tin labeled with Pantone number 8442 which starts with series 8 and ends with an even number so this ink tin should be placed on the side of the rack labeled "series starting with 1 and ending with the even number". The process was carried out for all tins and were organized on the racks.
Figure 69 shows the label designed for ink tins.

Figure 69 Lable for ink tins.

5. Later the room was cleaned and method of organizing ink tins on the racks were explained to the press operators. Procedures on how to use the racks were

documented and displayed next to the racks for operators understanding purposes and as part of work ethics.

Figure 70 shows ink tins organized in shelves with labels as indicators according to the Pantone numbers.

Figure 70 Ink tins arranged on shelves after implementation.

3.6.3 Implementation of PDCA

The implementation of printing plate system is gone ahead with the help of PDCA (plan, do check, act) cycle.

The plates arranged on the floor includes plates manufactured from the year 2005,till present. The management also said that there are plates outdated due to changes made from the client side. The plates used for the production process are picked by operators by searching in the place where the plates according to clients are placed. This time for retrieval of the plates for the production reported being high, so performance sheets were given to the operators for recording the time.

Table 3 Shows time taken by operators in retrieving the plates for various jobs before implementation.

Table 3 Time taken before implementation.

SL No	Job Number	Time-Taken
1.	173815	10 mins
2.	173780	15 mins
3.	173791	15 mins
4.	180085	10 mins
5.	171060	10 mins
6.	174604	30 mins
7.	174546	15 mins
8.	180018	40 mins
9.	174117	15 mins
10.	174085	15 mins

Jobs are carried out after wasting the production time in searching for plates and the average time in searching the plates for these ten jobs is 17 min and 5 seconds.

Implementation steps

1. By obtaining a list of companies that have made changes, the separation process will begin. The changes include updated logo of the clients, updated capitais sociais, most of the clients were private banks having new capitais sociais number. The separation process started by looking at the information on each plate and the preview sheet attached to it. Around 1000 plates considered waste during the process of separation.

Figure 71 shows the image of plates segregated while taking inventory and arranged on pallets.

Figure 71 Separation of plates in pallets

Figure 72 shows the image consisting data about capitais socials of various clients.

CAPITAIS SOCIAIS (Actualizado em 02/01/2018)

NOVO BANCO	€ 5.900.000.000,00	Email de 28/12/2017 Sr. Braga
NOVO BANCO DOS AÇORES	18.637.500,00 Euros	Email de 2014-11-01
[illegible] FUNDOS MOBILIÁRIOS	1.250.000,00 EUR	
[illegible] FUNDOS DE PENSÕES	1.000.000,00 EUR	
[illegible] FUNDOS MOBILIÁRIOS	3.000.000,00 EUR	
[illegible] GESTÃO DE ATIVOS	11.750.000,00 EUR	
[illegible] GESTÃO DE PATRIMÓNIOS	3.125.000,00 EUR	
Banco Económico	AOA 72.000.000.000,00	
Império [illegible]	202.005.400 Euros	
FIDELIDADE	381.150.000 €	E-mail de 05/09/2013 Cátia Costa/Sr. Braga
Caixa Geral de Depositos	3.844.143.735 €	E-mail de 05/04/2017 Sr. Braga/Cátia Costa
Millennium	5.600.738.053,72 Euros	E-mail de 2017-02-08 Sr. José João Ribeiro
ActivoBank	17.500.000 Euros	E-mail de 08/07/2014 Sr. Jorge Braga
Santander de Negócios	€ 26.250.000	
Santander Totta	1.256.723.284 €	E-mail de 31/03/2016 Sr. Moreira
Santander Totta	47.250.000,00 €	E-mail de 17/7/2009 Raul Rocha
BEATRIZ ÂNGELO	3.313.000 Euros	E-mail de 17/07/2017 Marisa Morais
HOSPITAL DA LUZ	250.000 Euros	
HOSPITAL DA LUZ	3.000.000 Euros	E-mail de 21/11/2017 Marisa Morais
HOSPITAL DA LUZ	2.100.000 €	E-mail de 28/12/2017 Marisa Morais
HOSPITAL DO MAR	250.000 Euros	
LUZ SAÚDE	95.542.254 Euros	E-mail de 11/02/2014 Raul Rocha / Sofia Chambino

CASAS DA CIDADE	2.000.000 €	E-mail de 28/12/2017 Marisa Morais
TopAtlântico	1.550.000,00 €	E-mail de 20/03/2012 Sr. António Moreira Sr. Carlos Martins
credibom	94.000.000 Euros	E-mail de 22/09/2016 Logística - Ligia Alves Sr. Braga
CA	18.000.000 Euros	
BPI	€ 990.000.000,00	E-mail de 20/06/2011 D. Elsa Sousa
BPI	€ 20.000.000	
BANCO CARREGOSA	€20.000.000,00	
[illegible]	13.566.000,00 Euros	E-mail de 15/02/2013 Braga /Sr. António Martins
BancoBIC	410.429.800,00€	10/08/2016 Email Sr. Moreira
ESEGUR	2.750.000 Euros	
Finicrédito	30.000.000 €	
GRUPO 8 - Vigilancia e Prevenção Electrónica, S.A.	€ 1.500.000,00	E-mail de 30/06/2015 Marta / João Lourenço
GRUPO 8	10.000,00 €	
MAPFRE SEGUROS GERAIS S.A.	33.108.650 €	
MAPFRE SEGUROS DE VIDA, S.A.	21.000.000,00 Euros	E-mail de 20/08/2014 Sandra Mendes
OK-TELESEGUROS	23.000.000 Euros	
Pastor Serfin	11.132.473,25 Euros	
LUSITANIA	€ 25.000.000	
LISGARANTE	50.000.000,00 €	
NORGARANTE	75.000.000,00 €	
GARVAL	50.000.000,00 €	

Figure 72 Information regarding captais socials.

2. The printing plates with information regarding client, job number, model number and date of manufacturing of the plates etc. used in creating a list of inventories of all the plates in Microsoft Excel.

Figure 73 shows information about the plate used in creating the inventory list of all the plates.

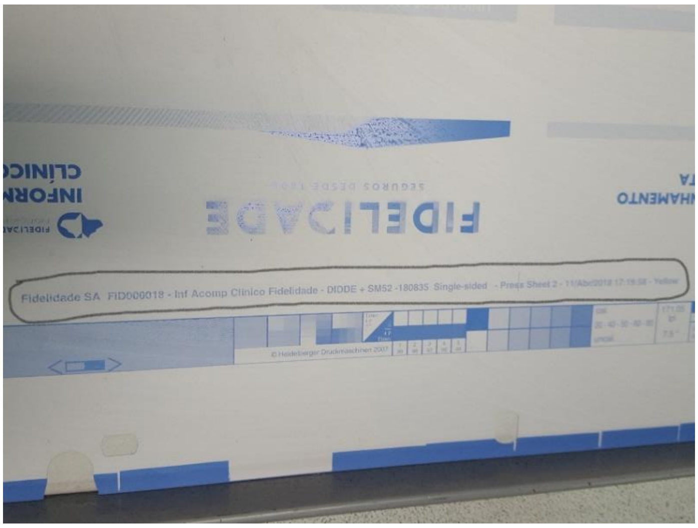


Figure 73 Information about the plate.

3. The company had resources where three racks each of 240 cm in length stacked one upon the other for the plates sizing 450 x 628 mm and another three racks of the same length for the plates sizing 605 x 745 mm were installed, respectively. The design of the system was discussed with a local carpenter and the dimensions recorded for the creation of a prototype.

Figure 74 shows the image of the prototype being created by placing the separators in between the slots for plates to be stored.

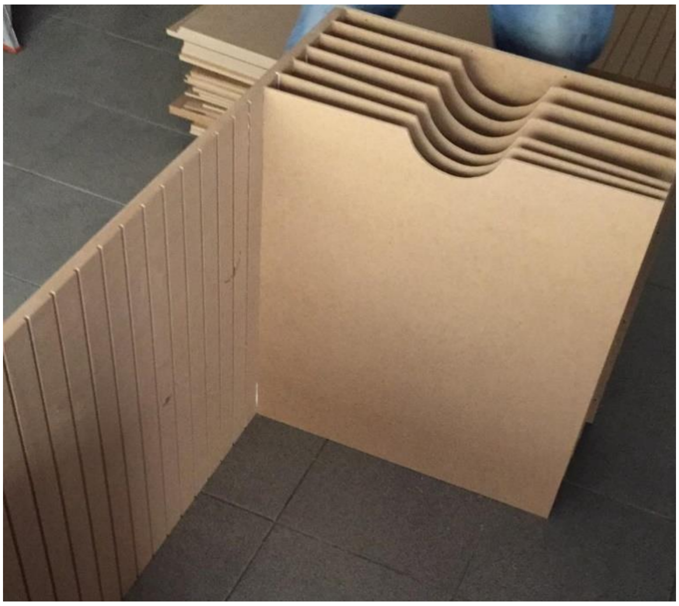


Figure 74 Image taken during the creation of the prototype.

4. The prototype of length 240 cm consisting of 27 slots each of 4 cm in width with separators in between the slots was designed and installed. The prototype was inspected by placing 35-40 plates of few job numbers on single slot and operators on the working floor were asked to pick a specific job from the plates that were kept in the slot. The operators were able to pick the specific job plates in the noticeably time span of 2 mins finally the entire system was made and installed for 450 x 628 mm and 605x745 mm size plates.
5. Plates belonging to a set of job numbers were placed into the slots, and their position in the system is mentioned in the inventory list. The position of the plates will be decided by an alphabet that stands for each row and the numbers for each slot. Considering a random job number 180176 say has 6 plates and they are kept in the 15th slot of row A, so the position of the plates of that specific job number will be A15. Similarly, all plates were arranged into the system, and their positions are updated in the inventory list.

Figure 75 shows the information about the plates organized in the system and their positions mentioned as slot numbers.

	A	B	C	D	E	F	G	H	I
1	s.no	company name	order no	no of plates	capitais sociais	Date of the plate	Model_No		SLOTS
2	1	NOVO BANCO	160958	2		3-12-16	MOD 1125		B41
3									
4			161050	1		30/3/2016	1A-04-GP		B41
5									
6									
7			175432	1	5,900,000,000.00	1-3-18	Mod 1252		B41
8			175177	2		20/12/2017	Mod 236		B41
9			175177	2		20/12/2017	MOD 236		
10			150785	2		3-4-15	MOD 970		B41
11	2	NOVO BANCO DOS ACORES	144673	1		21/11/2014	CAPAS LIVRO CHEQUES		B42
12			150537	1		2-9-15	CONTRA-CAPAS LIVRO CHEQUES		B42
13			163604	2		9-3-16		70111	B41
14			160600	2	18,637,500.00	24/2/2016	LIVRANCAS EM EUROS		B41
15			164305	5		04-nov		70014	B41
16									
17									
18									
19	3	GNB FUNDOS IMOBILLIARIOS	180790	2		28/2/2018	1A-09-FI		B42
20			144794	1		12-2-14	1A-09-FII		B42
21			150139	2	1,250,000.00	15/1/2015	CARTAS CONTINUCAO F1		B41
22			153399	2	1,250,000.00	30/9/2015	1B-01-FI		B41
23			[illegible]	1					
24			[illegible]	2					
25			153398	1		10-1-15	1A-01-FI		B41
26									
27									
28	4	GNB FUNDOS DE PENSOES	150347	1		23/1/2015	CARTAS 1A FOLHA		B41
29			180788	1	1,000,000.00	27/2/2018	1B-01-FP		B41
30			150147-150148	2		15/1/2015	CARTOES CUMPRIMENTOS 200X100		B42
31			150560	1		17/2/2015	1A-01-FP		B42
32			153391	1		10-1-15	1A-02-FP		B42

Figure 75 Inventory list of the plates.

6. Apart from the plates that were organized into a system, there are plates that will be manufactured for new jobs or any changes to the previous job will be regarded as new plates. Here the new plates will replace the plates of the previous job, and the job number is updated in the inventory list.
7. The system will become full by adding new plates, and this makes the system to be congested and difficult for operators to handle, to avoid this situation, some plates must be removed from the system.

Figure 76 shows the image of plates into the system with lables for identifying the plates at the respective slots.

Figure 76 image of plates organizeed with labels

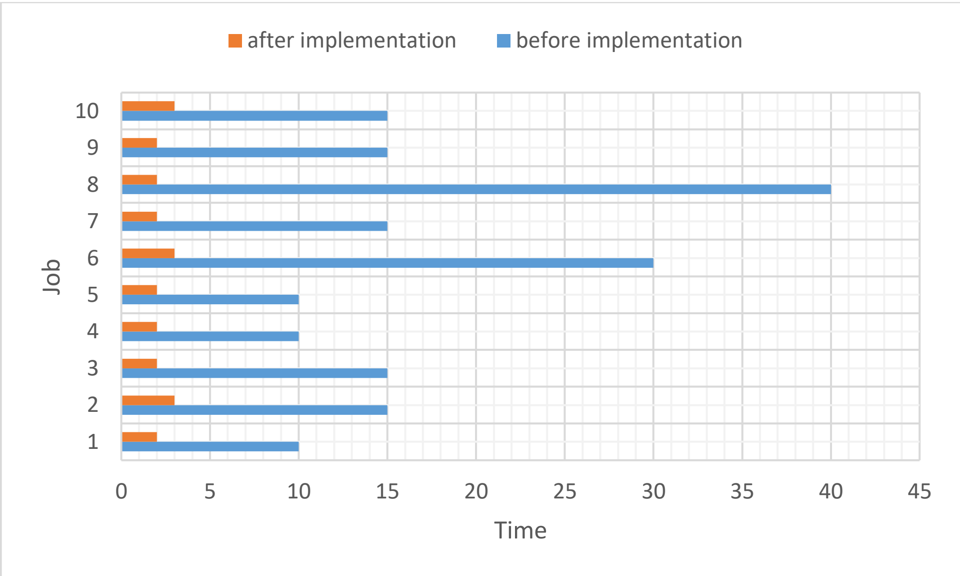
8. Removal of plates from the system needs either the plate should be outdated or changes in any job made from the client's side or when there is a complete change in for a new season from the client.
9. The system was full after organizing the plates and space for arranging new plates is gathered by removing old plates which are manufactured in 2010, 2011, 2012,2013. 400 plates were removed, giving space for new printing plates to rest in the system.
10. The system was set completely, and evaluating sheets were given to the operators of the production lines to make a note of the timing spent on retrieving the plates from the system.

Error! Reference source not found. shows the time taken by the operators in retrieving the plates for the jobs to be done. It also says that the time taken by operators has been reduced and the average time is taken in searching for the plates of the jobs found, reduced to 2 minutes and 3 secs.

Table 4 Time observation after implementation.

SL No	Job Number	Time Taken
1	153517	2 mins
2	174172	3 mins
3	163923	2 mins
4	180634	2 mins
5	170890	2 mins
6	181293	3 mins
7	162477	2 mins
8	173660	2 mins
9	173373	2 mins
10	162185	3mins

Chart/Graph 1 shows the comparison of the time-taken in retrieving the plates during before implementation and after implementation of the system.



Chart/Graph 1 Comparison of time on before and after implementation.

Figure 77 shows the image of plates organized on floor before implementation of the system for storing plates.

Figure 77 Before implementation.

Figure 78 shows the image of plates organized into the systems created with labels as indicators for slots and racks.

Figure 78 After implementation.

11. Systems of organizing plates for the plates sizing 459x525 mm and 605x745 mm, having a capacity of 6800 and 4000 were setup, respectively.
12. The system is reviewed often such that it does not overflow and causing the workers to adapt to the earlier situation of arranging the plates on the floor. Inspections are made to check whether there are old plates.

The cost of material used in making the system is 300€,

Labour cost in creating the system according to the specifications is 1700€

Total cost in creating systems for 2 different sizes is 2000 €, It is the responsibility of the management to be updated in the orders of the clients at each season and to follow the cycle to keep the system working.

4 SMED Practice

The Single Minute Exchange of die (SMED) tool is performed, when the setup process for the jobs seem to consume a lot of production time.At the end of each production, the products produced unloaded to a pallet, and the operator continues for the next setup process of production.Operator looking at the job sheet, searches for required printing plates or the operator will receive the plates in case if the job is new

Activities carried out before the setup operation are mentioned below:-

- The setup process includes cleaning/changing of plates,
- Changing ink at the printing bodies of the printing machine,
- filling up the paper tray at the feeding unit of the printing machine,
- cleaning of impression cylinder(rubber) in each printing body,
- changing the ink absorbing cloth at each head for every 24 jobs.

Implementation steps

1. The tool was performed on speedmaster 52-4, speedmaster 74-5 and the speedmaster 52-2 and data about the setup times for different jobs are gathered.

Table 5 shows the performed actions during the setup phase and their time averages

Table 5 Average time of actions performed on three machines.

Sl. no	Actions performed	SM 52-2	SM 52-4	SM 74-5
1	Cleaning of machine	3.3125	3.1175	3.828333
2	Searching the plate	0.9675	2.513333	1.2
3	Cleaning of plates	1.795	3.505	3.263333
4	Removing plate of the earlier job	1.6425	1.5825	1.53
5	Introducing ink	1.4325	2.413333	2.883333
6	Introducing plate and input	1.7575	2.9775	4.976667
7	Setting up paper	5.415	8.2425	11.45
8	Average setup time	16.3225	23.12	26.69

2. The actions performed during the calculation of setup times were almost similar in all the three machines. The average setup time calculated and found to be 16.32, 23.12, 26.69 for SM 52-2, SM 52-4, SM 74-5 machines, respectively.
3. The time is taken for the actions performed, compared with all the three machines and grouped as internal and external actions. i.e., The movement of the operation involving the work done during the setup process recorded as stop events occurring at the printing machines, on event log sheets in minutes with the help of stopwatch.

Table 6 shows the actions performed by the operators during the setup process segmented into internal and external actions.

Table 6 Performed actions categorized into internal and external

Internal actions	External actions
Changing of plates	Few prints were taken after setup
Changing/introducing ink	Production after setup
Cleaning of printing plates	Evaluation
Searching for needed printing sheets	
Searching for pallets for transferring finished products.	

4. The next step is the conversion of possible internal elements into external elements, i.e., actions performed during off state of the machine performed when the machine is running.
5. The total time spent on performing the internal actions is higher than the time spent on the external actions. Here the possible internal actions that can be performed during machine operation are searching, searching for needed printing sheets. An average of 5.415, 8.24,11.45 minutes spent in printing machines SM 52-2, SM 52-4, SM 74-5 respectively.in searching for new printing sheets and to get printed samples.
6. The average time spent on searching for the plates for the jobs is 2.51 in case of SM 54-5 and being less in the other two machines is because of new jobs. In the case of new jobs, plates are produced and handed over to the printing operators in prior.
7. The time on searching for new printing sheets and as well as cutting can be solved by having the right material flow to all the printing machines in the printing floor.

In explaining the scenario, places next to the printing machines of SM 52-2 and SM 52-4 are occupied by printed stock materials.

Figure 79 shows the picture of finished goods to be used for production stored at the production floor.

Figure 79 shows the space occupied by printed goods right near the printing machines.

Goods are mostly printed materials of invite cards, designation cards, documented forms of many clients, stored on pallets. The space occupied by these goods can be used for storing the printing sheets needed by the printing machines. The printed materials for production use can be stored at the huge shelves made for organizing the printing materials like coated papers and papers of different GSMs. These shelves must be categorized, labelled and organize printing papers according to their availability during production process.

Figure 80 shows the image of shelves for storing purposes near the loading area at the printing floor

Figure 80 Shelves for storing purposes.

The proposal is by hiring a worker performing the internal activities like searching of the plate, cleaning of plates, searching for needed papers, ink for production from the paint room and every other possible helps that an machine operator requires.

In the total production time of 10 hrs./day ,2 hrs. is spent on internal activities by the operators.

In justifying the above-mentioned proposal in hiring an employee,

Total production time wasted on the printing floor/day = 120 mins,

Production cost/ hr. on Speedmaster 52/2=30 €,

Production cost /hr. on Speedmaster 52/4 = 30 €,

Production cost /hr. on Speedmaster 74/5 = 60 €

The operators from SM 52/2 and SM 52/4 together and SM 74-5 consume 1 hour each respectively in doing all the internal operation for a day.

Total production loss. /day =120 €,

Total production loss. /month =120*20=2400 €,

The minimum wage of an employee in Portugal =676.67 €,

Total savings by hiring an employee for a month=2400-676.67=1723.33€.

So, by hiring an employee for all the printing machines, time spent in searching of the plate, cleaning of plates, cutting required papers, ink for production from the paint room, moving finished products to loading area can be conserved thereby increasing productivity in the company.

CONCLUSIONS

5 CONCLUSIONS AND PROPOSALS OF FUTURE WORKS

5.1 CONCLUSIONS

The study of lean tools and continuous improvement tools at the literature part of this thesis proves to be significant support in terms of knowledge about understanding waste and its different forms in the organization. The terms regarded as waste as discussed in section 2.3,2.4. The problems faced by the company at each scenario proven to contribute a considerable amount of time wastage in the setup process of the production.

The use of Ishikawa(fishbone diagram) a quality tool in addressing the root causes of the issues was proven useful and helped in providing a guideway in solving those causes, see section 3.4.1,3.4.2,3.4.3. The benefits observed in using Ishikawa were Understood and issues ewere analysed, Identify the root cause of the issue, Provide ways to improve the process related to the issue, In-depth in discussion of issue, Helps in prioritizing the analysis made and choosing corrective actions The corrective actions are analyzed by categorizing them according to strengths:- results that can be achieved using the corrective actions, weakness:- possible scenario where it can go wrong, opportunity to introduce something new that can improve the operation and threats involving the possible events where the actions reaches bottleneck and required inspections to be followed periodically. This helped in studying the system implemented in complete and futher update in working of the system, Section 3.5.1,3.5.2,3.5.3.

The implementation section 3.6 explains the corrective actions performed periodically for each problem reported by the organization of the company. Each implementation process is carried out following the steps involved in the tool adopted. The creation of tool room and tool chart involves the use of 5s along with Kanban shows the distribution, management of the tools at the production floor and management of tool room This created awareness about the use of tools, availability of the tools returning them to the pegboard, and cleanliness of the tool room after use. The arrangement of ink tins in shelves according to the Pantone number found to be helping the operators in obtaining the required ink tins quickly. Inspections gave improving results in following the procedure for arranging the tins by the operator when they have the need to create another Pantone color in a separate tin. The creation of systems for the arrangement of printing plates involves the use of PDCA during implementation which helped in planning the system with available resources, the capability of the system as well as the design of the system according to two different plate sizes. Results obtained after implementation found to be satisfying that the time taken for retrieving the plates from the systems has been reduced from an average of 17 minutes to 3 minutes. Minimized space in arranging the plates, records of the plates existing the system, updating the system whenever changes with clients occur are the improvements made regarding the printing plates. Finally SMED is performed in figuring out the setup activities and time involved in performing those activities, where the results of the setup times regarding the printing plates and ink from the paint room found to have contributed in the setup time of jobs carried at production units, but there are other activities like searching for required printing sheets for production consumes an average of 5.415, 8.24,11.45 minutes and seconds were recorded for the machine namely SM 52-2, SM 52-4, SM 74-5 respectively, see section 4. Proposals for solving the issue about acquiring required printing sheets mentioned in section 5.2

The use of lean tools and continuous improvement tools have proven to have made changes in terms of space occupied, the time taken in performing actions, effective management of tool room, tool chart and insight in solving other actions in the setup process.

5.2 PROPOSALS OF FUTURE WORKS

The work will be done for reducing the time needed to receive the printing sheet at each machine. This can be achieved by taking inventory of the goods present on the printing floor and then moving them in pallets to a separate place. ThePrinted goods are then moved to the storage room created, giving free space for the supply of printing sheets for the production process.on the printing floor. The created space will be segmented for allowing the required printing sheets for the job and for storing the finished products temporarily.

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6 REFERENCES AND OTHER SOURCES OF INFORMATION

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ANNEXES

7.1 ANNEX1

7 ANNEXES

This section consist of the supported documents involved in implementation of the tools as well as corrective actions carried out in solving the prblems reported by the organization.

7.1 ANNEX1

Based on latest capitais sociais and the Logo provided						
order no	no of plates	capitais sociais	Date of the plate	Model_No		SLOTS
160958	2		3-12-16	MOD 1125		B41
173867	1					
161050	1		30/3/2016	1A-04-GP		B41
141185-144186	2					
154180	2					
175432	1	5,900,000,000.00	1-3-18	Mod 1252		B41
175177	2		20/12/2017	Mod 236		B41
175177	2		20/12/2017	MOD 236		
150785	2		3-4-15	MOD 970		B41
144673	1		21/11/2014	CAPAS LIVRO CHEQUES		B42
				CONTRA-CAPAS LIVRO CHEQUES		
150537	1		2-9-15			B42
163604	2		9-3-16		70111	B41
		18,637,500.00				
160600	2		24/2/2016	LIVRANCAS EM EUROS		B41
164305	5		04-nov		70014	B41
180790	2		28/2/2018	1A-09-FI		B42
144794	1		12-2-14	1A-09-FII		B42
150139	2	1,250,000.00	15/1/2015	CARTAS CONTINUCAO F1		B41
153399	2	1,250,000.00	30/9/2015	1B-01-FI		B41
150559	1					
150823	2					
153398	1		10-1-15	1A-01-FI		B41
150347	1		23/1/2015	CARTAS 1A FOLHA		B41
180788	1	1,000,000.00	27/2/2018	1B-01-FP		B41
150147-150148	2		15/1/2015	CARTOES CUMPRIMENTOS 200X100		B42
150560	1		17/2/2015	1A-01-FP		B42
153391	1		10-1-15	1A-02-FP		B42
153390	1		10-1-15	1A-01-FP		B42
150093	1		15/1/2015	ENVELOPES C JANELA TAXA PAGA PENSOES		B41

153390	1		10-1-15	1A-01-FP		B42
150093	1		15/1/2015	ENVELOPES C JANELA TAXA PAGA PENSOES		B41
153018	1		14/8/2015	1A.09.FP		B41
150823	3		3-5-15	1A.09.FI		B41
150138	1	1,000,000.00				
150138	1					
150145-150146	2		15/1/2015	CARTOES CUMPRIMENTOS		B42
	3,000,000.00					
150140	1					
153389	1		30/9/2015	1B-01-FM		B41
150133-150135	1					
153387	1		10-1-15	1A-02-FM		B42
150556	1		17/2/2015	1A-01-FM		B41
153388	1		10-1-15	1A-01-FM		B41
150140	1					
	3,000,000.00					
153389	1					
150138-150140	2		15/1/2015	CARTAS CONTINUACAO		B41
150144	2		15/1/2015	CARTOES CUMPRIMENTOS		B42
150892	5		4-7-15	CARTEIRA MUNDANCA DE LOGO		B42
150150	5					
150563	1		17/2/2015	1B-01-GP		B41
153396	1	3,125,000.00				
153394	1		10-1-15	1B-02-GP		B42
150556	1					
153393	1		10-1-15	1A-01-GP		B42
150562	1		17/2/2015	1A-01-GP		B42
171789	3		20/4/2017	1A-07-GP		B41

151527	1		25/4/2015	202-007		A53
151525	1		25/4/2015	202-005		A53
151529	1		25/4/2015	202-009		A53
151528	1		25/4/2015	202-008		A53
151893	2		22/5/2015	B_0018-PAPEL CARTA		A53
151583	2		29/4/2015	LEVENTAMENTO POR CAIXA (DIDDE+SM52)		A52
170619	4	5,600,738,053,72	22/2/2017	10053038		A51
180514	2	5,600,738,053,72	28/2/2018	10053008		A51
153323	1		23/9/2015	10053105		A51
180045	1		19/1/2018	10053105		A51
175333	2	5,600,738,053,72	1-3-18	10053016		A51
172655	2		31/7/2017	10990338		A51
171557	1	5,600,738,053,72	4-11-17	10053188		A51
172654	2	5,600,738,053,72	31/7/2017	10990352		A51
153792+153793	1		15/10/2015	BIS A5 C_25FIS + 50FIS DR NUNO AMADO		A51
131113	3		5-7-13	10990338		A50
102005	3		28/5/2010	CONJ. TRIPTICOS CAMPANHAS PLANO VIP MINICIPIO PORTIMAO		A50
101912	10		18/5/2010	CONJ. TRIPTICOS CAMPANHAS PLANO VIP PANRICO		A50
101913	1		28/5/2010	CONJ. TRIPTICOS CAMPANHAS PLANO VIP EMP		A50
111664	3		30/5/2011	10050677		A50
121277	4		23/4/2012	10990338		A50
122749	4		15/8/2012	CARTAO ABERT CONTA PARTICULARES 85X55		A50
162779	2	5,600,738,053,72	29/7/2016	BCP 10053188		A51
104803	1		17/7/2014	10990117		A50
144720	4		25/11/2014	10070145		A50
161640	2		5-3-16	CARTS DR NUNO AMADO		A50
161638	2		5-6-16	ENV DL S_JAN SILIC DR NUNO AMADO		A50
151843	1		5-6-16	ENV DL S_JAN SILIC COM EXEC		A50
130046	2		5-6-16	BOLSAS C5 S JAN SILIC DR NUNO AMADO		A51
165229	2		28/12/2016	ENC C5 S_JAN SILIC ADMIN		A51
ORDER NO NIL	1		5-9-17	CARTOES VISITA MILENNIUM BCP 85X55		A51

AO ELECTRONICA						
153959	4	1,500,000.00	11-7-15	T10.G8_Ed.06		B39
180712	2		3-1-18	T11.G8_Ed.02		B39
152844	1		8-11-15	T06.G8_Ed.03		B39
152902	1		14/8/2015	T07.G8_Ed.04		B39
144121	1		7-11-16	T05.G8_Ed.03		B39
120394	1		2-8-12	T05.G8_Ed.02		B39
165178	1		1-4-17	T04.G8_Ed.05		B39
173925	1		18/9/2017	T21.G8_Ed.01		B39
112885	4		9-1-11	T26.G8_Ed.02		B39
174784	2			T14.G8_Ed.02		
174145	1		27/9/2017	T01.com_Ed.04		B39
order no nil	3		26/9/17	G8_alarmes		B39
170256	3		24/1/2017	T29.G8_Ed.02		B39
133762	2		10-10-13	T16.G8_Ed.01		B39
172857	2		7-5-17	T138.G8_Ed.02		B39
172875	2	1,500,000.00	7-10-17	T08.G8_Ed.04		B39
144984	1		15/12/2014	T15.G8_Ed.02		B39
order no nil	2		13/05/17	G8_alarmes		B40
172876	2	1,500,000.00	7-10-17	T09.G8_Ed.03		B40
162298	3			T22.G8_Ed.01		
order no nil	3		22/11/16	cartoes visita plano de 25 FV		B40
170264	1			T13.G8_Ed.02		
154137	1			T14.G8_Ed.02		
172544	2	1,500,000.00	6-12-17	T31.G8AL_Ed.01		B40
154497	1		12-1-15	T18.G8_Ed.01		B40
150371	1		21/5/2015	IMP.02.RS.Ed.02		B40
120428	3		2-10-12	T37.G8_Ed.01		B40
order no nil	2		3-9-15	cartoes visita plano de 8 FV		B40
150635	2		18/2/2015	T27.G8_Ed.02		B40
161023	2		24/3/2016	T38.G8_Ed.02		B40
133748	2		10-10-13	T33.G8_Ed.02		B39
133318	3		1-6-15	cartoes visita plano de 4 FV		B39
150633	2		23/2/2015	T02.G8_Ed.02		B39
170265	3	1,500,000.00	23/1/2017	T24.G8_Ed.01		B39
172854	2		7-10-17	T04.G8_Ed.05		B39

182023	1	15/5/2018	TLIS_DIR-DG_MOD02(0)		B8
180287	2	26/1/2018	TLIS_F&B-RT_MOD56		B8
161268	4	4-8-16	CASAS DO BARAO FOLHETO DE MAPA		B10
181553	8	4-12-18	TCAR_SPA-SP_MOD.36(1)		B10
180979	8	20/3/2018	TCAR_SPA-SP_MOD15		B10
180980	8	19/3/2018	TCAR_SPA-SP_MOD16		B11
180977	8	19/3/2018	TCAR_SPA-SP_MOD36		B15
180981+180982	4	19/3/2018	SPA A4 PT+EN		B10
180975+180976	4	20/3/2018	questionario satisfacao cliente SPA PT+EN		B10
172289	4	23/5/2017	TLIS_ALJ-RC_MOD41(2)		B8
172314	5	22/5/2017	TLIS_ALJ-FO_MOD53(0)		B8
180459	4	28/2/2018	TLIS_ALJ-HK_MOD01(1)		B8
180838	4	3-1-18	TCAR_ALJ-FO_MOD16(0)		B7
172287	3	3-2-18	TLIS_ALJ-RC_MOD02(0)		B8
173578	7	28/2/2018	TLIS_ALJ-HK_MOD06(0)		B8
180027	13	2-7-18	TLIS_F&B-RT_MOD07	REPEAT 3	B7
180296	4	31/1/2018	TLIS_F&B-RT_MOD11		
180027	4	29/1/2018	TLIS_F&B-RT_MOD07		
180027	4	29/1/2018	TLIS_F&B-RT_MOD07		
180319	4	29/1/2018	TMVL_SPA-SP_MOD12		B10
180318	4	29/1/2018	TMVL_SPA-SP_MOD011		B10
172706	1	23/6/2017	TLIS_ALJ-AN_MOD04(0)		B8
180246	1	23/1/2018	TLIS_ALJ-AN_MOD04(0)		B8
175119	1	1-12-18	TMPO_DIR-DG_MOD08(4)		B9
173016	2	7-6-17	TLIS_DCP-OT_MOD36(0)		B8
174309	2	12-out	TLIS_DIR-DG_MOD48(0)		B7
172715	1	28/6/2017	TLIS_ALJ-HK_MOD63(0)		B8
174688	1	11-6-17	TLIS_DIR-DG_MOD07(0)		B7
172711	4	23/6/2017	TLIS_ALJ-HK_MOD61(0)		B7
172274	2	15/9/2017	TLIS_F&B-RT_MOD31(0)		B7
173621	3	24/8/2017	TLIS_F&B-RT_MOD06(0)		B7
172843	1	7-3-17	TLIS_DIR-DG_MOD37(0)		B7
173783	1	25/8/2017	TLIS_F&B-RT_MOD05(0)		B9
173782	1	25/8/2017	TLIS_F&B-RT_MOD41(0)		B9
173204	2	27/7/2017	TLIS_ALJ-FO_MOD66(0)		B9
172296	2	27/6/2017	TLIS_F&B-MB_MOD01(0)		B9