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Lean Manufacturing Production Management Model using the Johnson Method Approach to Reduce Delivery Delays for Printing Production Lines in the Digital Graphic Design Industry

A Gomero-Campos[1], R Mejia-Huayhua[1], C Leon-Chavarri[1], C Raymundo-Ibañez[2, 4] and F Dominguez[3]

[1] Ingeniería Industrial, Universidad Peruana de Ciencias Aplicadas (UPC), Lima 15023, Perú.
[2] Dirección de Investigación, Universidad Peruana de Ciencias Aplicadas (UPC), Lima 15023, Perú.
[3]Escuela Superior de Ingeniería Informática, Universidad Rey Juan Carlos, Mostoles, 28933, España.

E-mail: carlos.raymundo@upc.edu.pe

Abstract. Several factors compel graphic design companies to improve efficiency and competitiveness in their production lines. However, these companies are not prepared to take on this challenge, as they report delays in 20% of their deliveries, caused by high setup times, low machine availability, and poor work scheduling. In this context, this study proposes a new production management model fed by the interaction of lean manufacturing tools and the Johnson scheduling method. This model has been validated by direct application at the SISSA. The results obtained were the reduction of the setup time to 15 minutes, increased machine availability up to 24%, and an efficient scheduling of its tasks. All of these reduced the percentage of delivery delays from 20% to 6%.

1. Introduction

The graphic design industry worldwide has been recovering from the double impact it has suffered as a result of the global financial crisis and digital revolution. Nonetheless, among its different printing technologies, digital technology companies record the largest growth in both income and printing volumes. However, this growth has stagnated in regions such as Africa and South America (Andigraf Magazine). In South America, the country that has distinguished itself as one of the countries with the greatest economic dynamism is Peru wherein the graphic design industry is expected to recover, which compels companies to adapt and face new challenges that the market brings (Interempresas Magazine).

The Peruvian printing industry is one of the most emerging industries in the country owing to the quality of its work and competitive prices. According to the AGUDI Magazine, more than 9800 companies comprise the graphic design industry, which include printing activities (86%), publishing

[4] To whom any correspondence should be addressed.

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activities (8%), paper manufacturing and production activities (5%), and others (1%). The Ministry of Production's report on printing activity productivity reveals that they experienced a 6.9% decrease in production in the first quarter of 2017 compared to the first quarter of 2016, and in the following year, a 1.8% decrease in quarterly production in 2018 was observed compared to the production levels reported for 2017.

This has forced the domestic market into a highly competitive environment, characterized by the industry's need to implement more agile and efficient production systems that can meet the increasingly personalized demand in terms of lead time and quality.

This report seeks to present a solution to the critical issues facing the graphic design industry by using engineering tools that can reduce production times. To this end, the authors propose the use of a production management system focused on work and process organization. The low success rates that the Lean technique has had thus far may be attributable to the fact that the authors have not considered the low-volume production and high product variability of this industry. Additionally, according to the Comunigraf Magazine, the printing industry deals with the lack of production planning and often does not have a job scheduling system. Moreover, when implementing the Lean manufacturing technique, scheduling problems tend to precede the waste presented. To achieve this, we proposed a production management model focused on workplace organization (5S) and process organization (Lean manufacturing) supplemented by proper work scheduling (Johnson method).

2. State of the art

2.1. Lean Manufacturing

The lack of a methodology to help diagnose the current state of companies and to identify production waste factors is one of the reasons why managers cannot make improvements. Value Stream Mapping (VSM) has proven to be one of the most useful diagnostic tools for manufacturing companies, as it helps identify more than waste and provides improvement opportunities for manufacturing factory managers. After identifying improvement opportunities for production lines, it is necessary to opt for solution techniques related to the problems found [1] [2] [3] [4]. One of the Lean manufacturing techniques is the Single-Minute Exchange of Dies (SMED), which involves separation and conversion of internal setup operations into external operations and aims at achieving setup times in less than ten minutes.

This technique was first used on stamping presses, but its applicability was later extended to other machines. SMED has proven to be effective in reducing cycle times. However, the authors state that besides focusing on cycle times, workplace cooperation is also required, and the technique has been improved by additional procedures involving the 5S method, which also improves workplace environment and relationships. The implementation of the SMED technique coupled with the 5S method has resulted in great improvements, increasing SMED effectiveness [5] [6]. On the contrary, the Total Productive Maintenance (TPM) technique is an innovative approach to maintenance that optimizes equipment effectiveness, eliminates breakdowns, and promotes autonomous maintenance for operators through day-to-day activities. Researchers show that successful TPM implementation in an organization largely depends on the organization's effort to comprehensively implement TPM initiatives. In addition to commitment, support, and involvement from senior management, developing a realistic TPM implementation plan, instilling skills and knowledge related to autonomous maintenance, and improvement in equipment is required. TPM implementation not only improves the Overall Equipment Effectiveness (OEE) of large industries but also OEE rates at small industries through an innovative strategy [6] [7] [8] [9].

2.2. Johnson Method

The abovementioned techniques (SMED and TPM) are used to improve production processes by eliminating waste. However, these "Lean" techniques are still at an early stage of implementation in printing companies, having a low "Lean" implementation success rate of 5% compared to other

manufacturing industries, which report up to 46%. This may be grounded in the fact that past authors have not considered this industry to be characterized by low-volume production and high product variability. This research aims at implementing, prior to "Lean" tools, a scheduling methodology for print jobs related to the areas involved and at giving rise to the implementation of the "Lean" tools mentioned [7] [10] [11].

3. Contributions

3.1. Proposed Model

This research proposes a production management model focused on the two production dimensions shown in Figure 1:

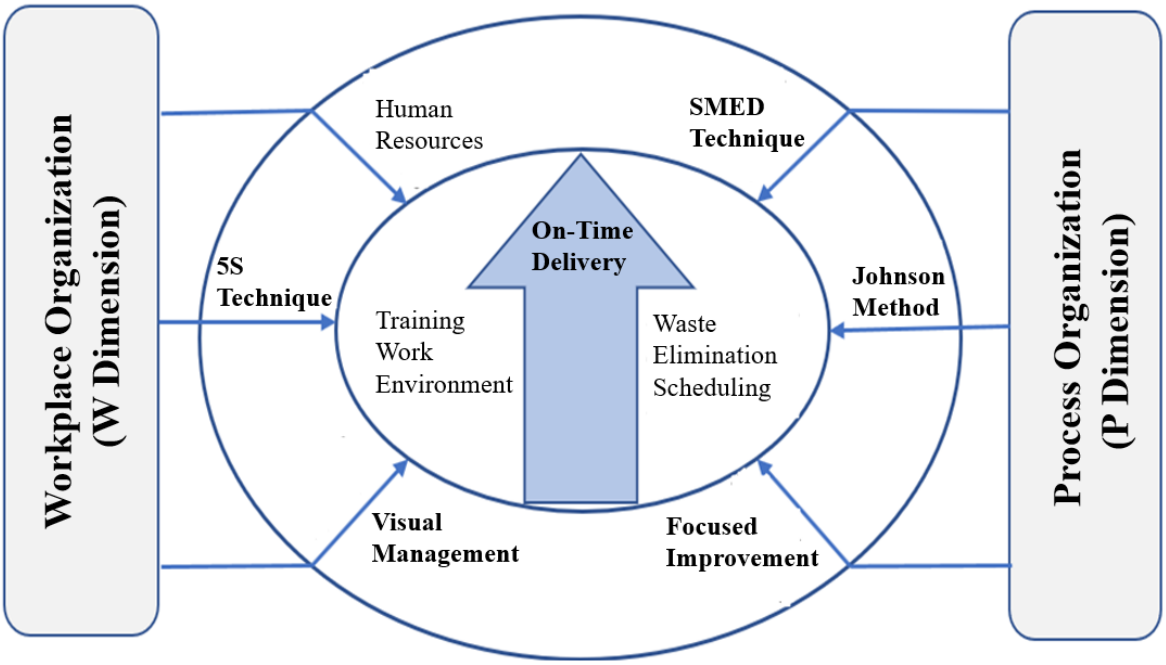

Figure 1. Proposed production management model

The first dimension to be implemented in the model is the W dimension, which is based on the following techniques:

- 5S is an important component in the context of a previous implementation of Lean manufacturing methodologies aiming at generating order and discipline and managing activities on the implementation site.
- Visual Management is a technique that aims at improving process efficiency based on graphics and colours.
- Improving human resources management is a component that focuses on employee training to increase their awareness and commitment, thereby improving workplace environment and enhancing productivity.

On the contrary, the P dimension comprises improving the production processes for which the following techniques are implemented:

- Lean Manufacturing (SMED and Focused Improvement)—a methodology to increase productivity by reducing cycle times and increasing machine availability

- Johnson method—a technique used to efficiently schedule the production jobs to fulfill product deliveries

3.2. Proposed Method

The implementation of the proposed model is described in four stages based on the development of the following main techniques to be developed:

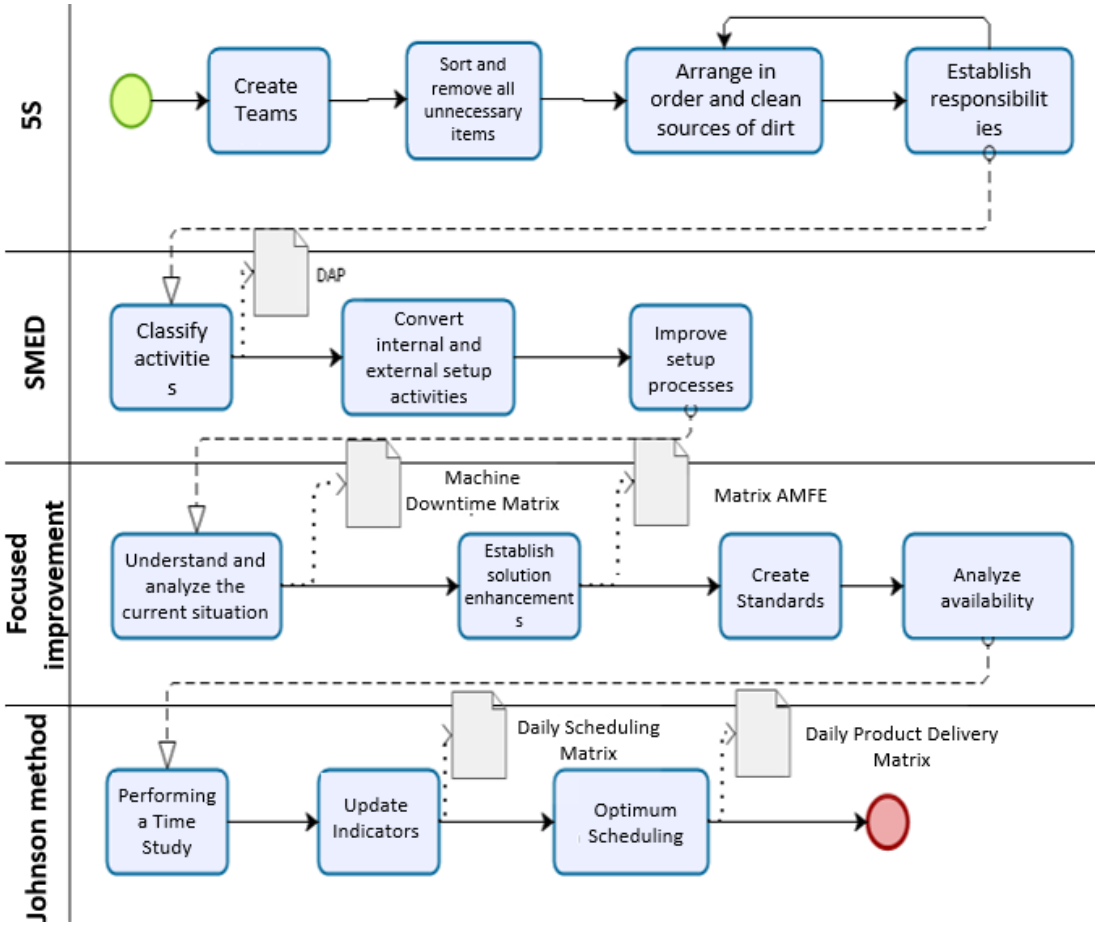

Figure 2. Implementation flowchart

3.3. Ratios

The proposed model aims at generating a more efficient and competitive production line in the digital printing industry, which requires an analysis of ratios that help meet the proposed objective.

3.3.1. On-Time Delivery. Goal: To measure compliance in the delivery of SPs on the agreed date (achieve 90% compliance).

Formula:

$$On-Time\ Delivery\ (\%) = \frac{No.of\ on-time\ delivered\ orders}{Total\ no.of\ orders\ delivered}\ 100\% \quad (1)$$

3.3.2. Machine Availability. Goal: To measure equipment availability and classify the company's competitiveness and reach 85% availability.

Formula:

$$Availability\ (\%) = \frac{(total\ hours - machine\ downtime)}{total\ hours} \quad (2)$$

3.3.3. Setup Time. Goal: To reduce the setup time caused by machine downtime to or less than 15 minutes. Formula:

$$Average\ Set\ up\ time = \frac{Cumulative\ Set\ up\ time}{Total\ downtime\ due\ to\ Set\ up} \quad (3)$$

3.3.4. Idle Time due to Scheduling. Goal: To reduce idle time due to scheduling to 0.
Formula:

$$Idle\ Time = Total\ Available\ Hours - Actual\ Hours\ Worked \quad (4)$$

4. Validation

4.1. Case Study

This section discusses the Lean manufacturing methodologies applied along with the Johnson method in a production management model at a digital printing company and the impact that they exerted as per the objectives set.

Sistema de Impresiones S.A. was established in 1994, and since its inception, the company has been dedicated to designing and printing Point-of-Sales (POS) marketing collateral items using the on-demand production system on different types of substrates to respond to customer demands. To manufacture a wide range of products and to remain flexible as per changing customer needs, the company uses different types of substrates such as banners, vinyl, cardboard, sintra, and foam among others. Furthermore, the company counts on the machinery necessary to print on any material as per customer instructions.

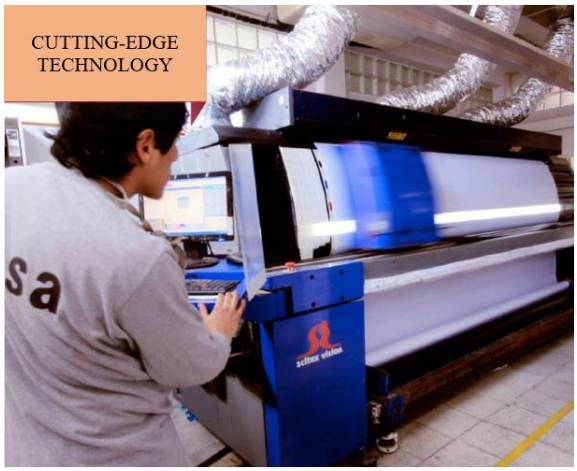

Figure 3. An image from the company

4.2. Situation

One of the main problems faced by Sistema de Impresiones S.A. is its continuous loss of contracts. According to the company, some of their regular clients have decided not to award them contracts because they have found other providers who can best meet their requirements. This issue is rooted in late and damaged deliveries. The on-time delivery rate averages 79.8% owing to different factors that increase the amount of time lost each month.

Subsequently, a 70% machine availability rate was achieved. The desired availability for the printing industry should exceed 85% of total hours. In fact, Sistema de Impresiones has been found to record up to 2.5 idle hours per day because of poor work scheduling and lack of clear procedure standardization.

4.3. Implementation

The following activity scheduling was taken into account for the implementation:

- Implementation Kick-off
- Initial Audit
- 5S Implementation
- SMED Implementation
- Focused Improvement Implementation
- Johnson Method Implementation

- 5S implementation focused on engaging employees and making them aware that their activities are essential for order fulfilment. Therefore, they must be able to distinguish between non-value-added activities and activities that increase productivity. Thus, both productivity and work environment are improved.
- During SMED implementation, we identified all the printing process activities and activities that can be performed by previous or following processes.

To this end, we created a Process Analysis Diagram to identify all the activities; then, using a time study, we obtained average times for each activity. Subsequently, we identified the internal setup activities that will become external. Finally, the remaining internal setup activities were improved by reducing non-productive times, as shown in Table 1 below. Activity times were reduced to an average of 40.6 minutes; setup times were reduced to 15 minutes; and non-value-added activities were eliminated.

- For focused improvement, we created an FMEA matrix that identified the most relevant potential RPNs for potential failure: tray printing. Next, arrangements were established for focused maintenance. Machine availability increased to 93%, which presents a statistical error of 0.06 in a t-student test.
- Then, the Johnson method was implemented for effective job scheduling and order fulfilment planning.

Thereafter (i.e., after applying the Johnson method), the on-time delivery trend increased in April. In fact, in the weeks following the implementation, it reached an average of 93%.

4.4. Results

The other assessed indicators included machine availability and setup time. Table 1 depicts how these indicators have changed after deploying the model proposed in the digital printing industry.

Table 1. Results achieved

	Before	**After**
Availability	70%	93%
Time Setup	25 min	15 min
Idle Hours	2.5 h/day	0 h/day
On-Time Delivery	79%	93%

The post-model implementation results obtained were positive, as according to the above traffic light indicator, these results are within the industry expectations in terms of a more efficient production line.

5. Conclusions

This research aimed at decreasing lead times for a printing production line that resulted in late deliveries to customers. After the application of a set of Lean tools in conjunction with the Johnson Scheduling Method, lead times experienced a 12% reduction. The implementation of this model will allow companies to meet their production plans with the least possible number of downtimes and machine breakdowns. Thus, the sector may focus its efforts to continue growing under constant optimization strategies, offering quality products to customers, and, above all, fulfilling their orders on time. Hence, companies operating within the sector may better satisfy customer demands and reduce their percentage of contract losses. In spite of the positive results obtained from applying the model in the printing production line, an approximate loss of 50 hours per month remains because of non-value-added activities. Therefore, the development of a Process Management System can be considered to help reduce these activities and to increase on-time delivery rates.

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