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Lean Manufacturing Production Management Model focused on Worker Empowerment aimed at increasing Production Efficiency in the textile sector

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Lean Manufacturing Production Management Model focused on Worker Empowerment aimed at increasing Production Efficiency in the textile sector

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Abstract. For companies operating within the garment manufacturing industry, having frequent downtimes in their production flows is an extremely common issue. In this context, a balanced production line is required to prevent high waiting times due to limited productive capacity. A well-balanced assembly line allows products to be produced in an optimum time while using less resources, such as machines, materials, or labour, since the right number of products is produced with the exact amount of resources, thus generating savings in production costs. This paper seeks to foster optimum resource allocation through the line balancing tool. Finally, to define a work methodology, best practices were selected, and a procedures manual was developed focusing on Standardization. Both tools were implemented after implementing changes to the company culture by means of the Employee Empowerment tool. As a result of this implementation, workers acquired greater accountability and control over the resources, methods, and equipment of their work areas. After the proposed improvements had been deployed, the company reported an increase of over 20% in production line quality, performance, and efficiency.

1. Introduction
In the last decade, the Peruvian economy has reported an average annual growth of 4.3% [1]. One of the reasons for this feeble growth is that local companies, whether micro-, small-, or medium-sized enterprises, face different problems that affect their productivity levels, which in turn exerts a negative impact on their competitiveness at international levels. In this context, textile and clothing MSMEs play a leading role in the Peruvian business fabric since they represent one of the main non-extractive activities at the national level, accounting for 1.3% of the national GDP and 8.9% of the manufacturing production in 2014 [2]. Therefore, the textile and clothing sector has become the second most important sector within the manufacturing GDP, only surpassed by the precious and non-

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ferrous metals industry. However, despite its production value growing approximately 14.8% between 2009 and 2014, the textile industry exhibited, from January to August 2017, a cumulative negative growth rate of 6.5%, while for the last 12 months, the variation was negative, approximately 6.0% [1]. Therefore, the root causes for this issue must be determined.

This study seeks to describe current sector performance and propose an improvement model to avert downtimes and raise the productive efficiency of the company. In addition, this study may also serve as an example for other garment manufacturing companies toward better production controls and development. To this end, Value Stream Mapping and the 7 Wastes were used as assessment tools in the identification of the main problem the company under study is facing. Finally, a line balancing model was developed and implemented to appropriately allocate resources according to each workstation.

2. State of The Art

2.1. Lean Manufacturing in the Textile and Clothing Sector

According to past research, the application of Lean Manufacturing techniques has had positive results in various production processes, improving efficiency, productivity, and quality. Since the Lean philosophy supports the adaptation of different techniques, actions or activities that do not add value to production processes may be easily identified for their subsequent reduction or elimination, which leads to lower production costs and increased product quality [3]. In this light, Psomas, E., and Antony, J. [4] argue that Lean Manufacturing can address different problems arising during the garment production process, such as overproduction, reprocessing, excess inventory, movements, unnecessary transportation, defective products, and process delays. In addition, this study engages two additional tools: Line Balancing and Standardization

Line Balancing focuses on grouping activities that follow a work sequence at a production plant, which, in this case, is a textile production plant; this is meant for achieving maximum use of resources. According to Oksuz, M.K. [5] and Türkmen, A. [6], one of the main objectives of line balancing is eliminating bottlenecks and production delays. Among the most relevant line Bblancing models are the Moddie Young and the Hoffman methods. Furthermore, K. Syahputri [7] and M. Kayar [8] compare the efficiency and assembly line balancing losses at a textile manufacturing company in Asia, reporting a 15% gap between the Hoffman model and the Moddie Young model when measuring line balancing efficiencies.

On the contrary, work standardization is the main premise for achieving accurate quality results. Therein, a sequence of steps through which identical results can be achieved in terms of time, procedure, work technique, product, and quality are designated. Standardization is an essential part of any viable production. Processes (work methods) at different complexity levels are known as standard work methods.

2.2. Worker Empowerment Applied to the Textile and Clothing Sector

KH Blanchard and JP Carlos [9] argue that Worker Empowerment is a management strategy that allows employees to develop their own skills for becoming competent in making their own decisions. In fact, one of the studies reviewed developed a visual combination model based on resources, Signalling theory, and Experiential Learning theory. This model is then validated through its implementation in 653 employees working in textile production companies. These findings suggest that a culture of organizational learning significantly strengthens team building relationships and worker empowerment in employee competencies. [10] The results conclude that companies must provide sufficient training time for employees to develop an appropriate culture and effective communications within the company.

3. Contributions

3.1. Proposed Model

- Phase 1: Value Stream Mapping diagram, the production flow of the company. This tool identifies lead time along with the times that add and do not add value.
- Phase 2: Line Balancing to optimally allocate resources and balance production lines.
- Phase 3: Standardization to establish the appropriate work methods.
- The above is based on Worker Empowerment, which seeks to generate total work area ownership and accountability in operators.

Each component added to this production management model not only fosters production efficiency but also implementation sustainability. That is, it guarantees that the implementation will remain operational over time.

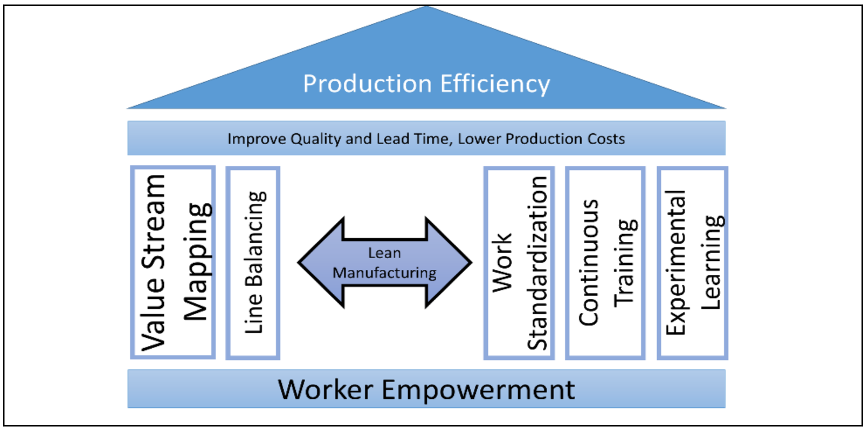


Figure 1. Proposed model

3.2. Proposed Method
This item explains the steps required for deploying the production management model as explained below (Figure 2).

3.3. Indicators

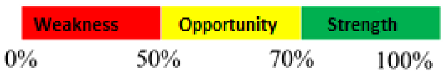
3.3.1. Production Line Losses and Efficiency. These indicators identify the current status of production line flows to determine whether bottlenecks have been successfully removed.

$$LB = [(nC - \Sigma\ Co)/nC)]\ 100 \tag{1}$$

$$LE = (1 - LB)\ 100$$

3.3.2. Overall Efficiency. Overall Equipment Efficiency, or OEE, is an indicator which measures the efficiency with which a piece of equipment or process works.

$$OEE = Availability\ x\ Performance\ x\ Quality\ Rate \tag{2}$$



3.3.3. Performance. This aspect assesses the speed percentage with which machines actually operate against their design speed.

$$Performance = \frac{\frac{Cycle\ Time}{TO}}{Total\ Units\ Produced} \tag{3}$$

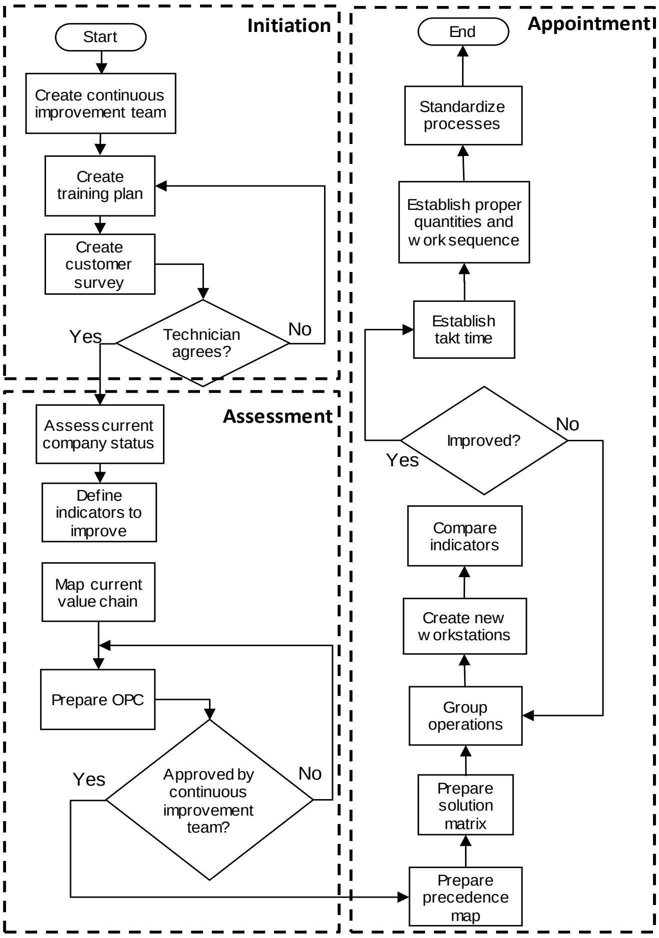


Figure 2. Proposed method

3.3.4. Quality. This aspect determines the number of products manufactured within the required quality levels and which are not rejected.

$$Quality = \frac{Comforming\ Units}{Total\ Units\ Produced} \tag{4}$$

3.3.5. Availability. This aspect assesses the percentage of time that is actually worked against the time scheduled for working.

$$Availability = \frac{TPO - Unscheduled\ Stops}{Total\ Work\ Time - Scheduled\ Stops} \tag{5}$$

4. Validation

4.1. Description

The company under study manufactures and markets garments for babies, boys, and girls. Its facilities include a work area of 500 m2, wherein 23 workers operate about 30 machines between sewing machines, overlock sewing machines, embroidery machines, and others. Located in the district of San Luis in Lima, Peru, the company was established in 2013, which evidences that it is still a developing company (Figure 3).

Figure 3. Case study

Recently, this company has been in dire economic straits in terms of achieving its objectives. Although, in recent years, the company sales have increased from s./5,041,388 to s./6,119,531, that is a 21% increase. Costs increased in over 33%, which is a matter of concern for the company.

4.2. Assessment
Since the company produces a large number of products, the ABC methodology was used to determine which products within the same production line represented higher revenue in sales for the company. Based on our findings, polo shirts and blouses were selected as the flagship products. Next, the Value Stream Mapping diagram was plotted, establishing that from a lead time of 13.5 days, a total of 6.5 days was found not to add value to the production process. These days are associated to the sewing process, which generates frequent bottlenecks at this station.

Finally, to identify the causes of the evidenced discontinuous production flow, the 7 Wastes tool is used, which identifies overstock inventories and reprocesses as the most likely causes.

4.3. Method Implementation
Step 1: Preparation of the Operations Process Chart

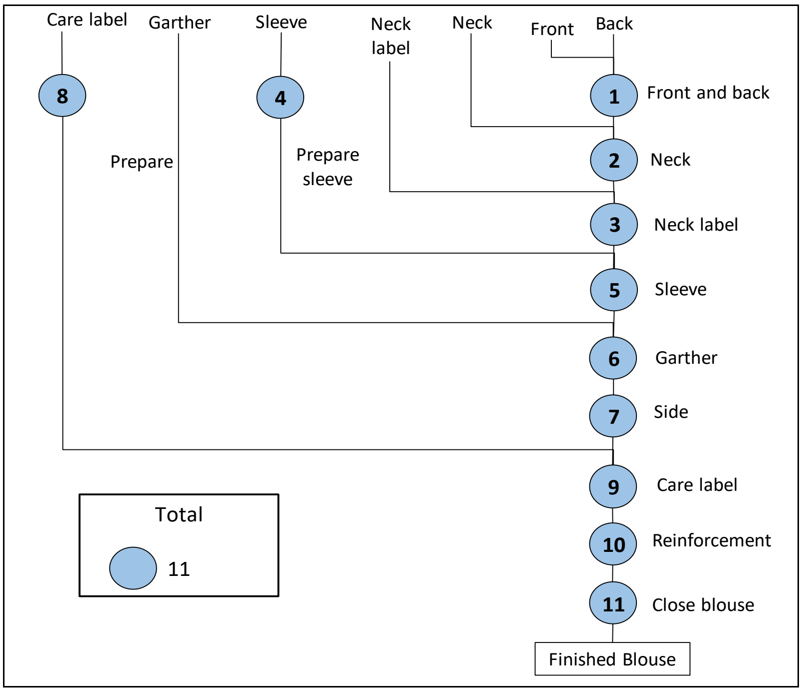


Figure 4. OPC-Blouse sewing process

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Step 2: Calculate balance losses with the standard times.

$$LB = (11x0.98-19.84) / (11x0.98)\ X\ 100 = 44.16\% \quad (6)$$

$$LE = (1-0.4416)\ x100 = 55.84\% \quad (7)$$

Step 3: Leopold Matrix, grouping unprecedented activities.

OP	1	2	3	4	5	6	7	8	9	10	11
1		1									
2			1								
3					1						
4					1						
5						1					
6							1				
7									1		
8									1		
9										1	
10											1
11											
	0	1	1	0	2	1	1	0	2	1	1

Figure 5. Leopold matrix

Step 4: Reduce activities through a priority matrix.

	Activity	Time	Total	Difference
1	1	0.74	0.74	0.24
2	2	0.52	0.72	0.26
	10	0.2		
3	3	0.25	0.75	0.23
	6	0.5		
4	4	0.48	0.86	0.12
	8	0.38		
5	5	0.62	0.62	0.36
6	7	0.65	0.65	0.33
7	9	0.7	0.7	0.28
8	11	0.98	0.98	0

Figure 6. Activity matrix

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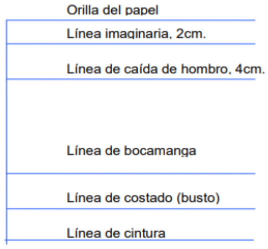
Step 5: Standardize the new process line through a procedure manual.

Manual de procedimiento de la confección de una blusa

La base para la confección de una blusa, es el trazo de 5 líneas incluyendo la línea imaginaria, llamadas líneas de construcción que son:

1. Línea imaginaria; esta se traza midiendo 2 cms. de la orilla del papel, hacia abajo.
2. Línea de caída de hombro; se traza de la línea imaginaria 4 ó 5cm. hacia abajo.
3. Línea de sisa; se traza de la línea de cintura, hacia arriba, se anota la medida de costado.
4. Línea de bocamanga; se traza a la mitad de lo que mide la línea de caída de hombro y la línea de costado (busto).
5. Línea de cintura; esta se traza de la línea imaginaria, hasta donde mide el largo de espalda o de frente.

Ejemplo de las líneas para la confección de la blusa



2. Medidas básicas para confeccionar una blusa:

- Trasero:

Son los centímetros que mide la parte de atrás, iniciando siempre en la parte alta del cuello hasta llegar a la cintura.

Se toman dos medidas:

a) Ancho de espalda; referido a la distancia en cms. que hay entre los hombros. Para ello se inicia a tomar la medida del hombro izquierdo hasta finalizar en el hombro derecho.

Figure 7. Sewing procedure manual

- With the line balancing, three activities were deemed unprecedented, which led to line balancing of almost 77%.
- With Standardization, a procedure manual was designed for the sewing area. Then, the manual was disseminated among all operators in the area as printed newsletters.
- Worker Empowerment was carried out through Autonomous Maintenance, one of the pillars of Total Production Maintenance. Here, by implementing actions to clean, adjust, and lubricate, workers were able to take ownership and become accountable over their work areas.

The following table shows the improvements achieved:

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Table 1. Before and after results

Tool	Indicators	Before	After
Standarization	Quality	54.79%	83.67%
TPM	Availability	97.78%	95.00%
Line Balancing	Performance	85.03%	95.25%
OEE		43.22%	75.62%

OEE: A 75.62% OEE rate was achieved, which ranks within the acceptable range for productive efficiency.

5. Conclusion

- The proposed model identified high in-process inventories and the quantity of reprocesses within the manufacturing area as the main causes for the problem addressed. This problem was evident when the discontinuous flow of garment production reported a lead time of 13.5 days, whereas the market average does not even exceed 10 days.
- Therefore, the application of the line balancing and Standardization Lean tools to the garment product process removed the two wastes which exerted the greatest economic impact on the company. In addition, production line efficiency also increased from 55.88% to 76.79%.
- Further, the application of the Standardization tool minimized response times for a specific problem, which allowed us to increase our individual efficiency and effectiveness ratios at the company level.

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