Production Management Method Based on Agile Approach and Lean Manufacturing Tools to Increase Production Levels in Peruvian Metalworking MSMEs

David Portugal-Picon[1], Manuel Villavicencio-Arriola[1], Mercedes Cano-Lazarte[1], and Carlos Raymundo[2(✉)]

[1] Ingenieria de Gestion Empresarial, Universidad Peruana de Ciencias Aplicadas, Prolongacion Primavera 2390, Lima 15023, Peru
{u201416903,u201410791,pcgemcan}@upc.edu.pe
[2] Direccion de Investigacion, Universidad Peruana de Ciencias Aplicadas, Prolongacion Primavera 2390, Lima 15023, Peru
carlos.raymundo@upc.edu.pe

Abstract. In Perú, 90% of companies that employ 50 workers or less have an average life span of only 10 months in the market. This statistic is closely linked to informality and low productivity issues in such companies. Moreover, in March 2020, manufacturing production plummeted to 32.2% owing to low productivity levels exhibited by some companies. Therefore, to improve this situation, a production management method is required to enhance production management at metalworking MSMEs. This research work is based on the design and application of a production method based on lean manufacturing tools and agile methodologies to improve production process performance and meet market demands. Results revealed that manufacturing times reduced to 14.5 min, productivity increased by 30%, and the level of unfulfilled orders reduced by 30%.

Keywords: Agile methodologies · Lean manufacturing · Lean production · Productivity · SMEs

1 Introduction

Currently, the informality and poor management skills of microbusiness owners have led to a significant decrease in the sales of MSMEs, which potentially decreases their productivity levels. According to the Development Bank of Latin America—CAF, regional production growth has been extremely low in Latin America for the last 60 years. In fact, the productivity of Latin American countries accounts for only 27% of that reported by the United States [1]. The manufacturing sector has also been impacted at a global scale owing to the slow growth, sustaining 3.6% of the manufacturing-added value in 2018 relative to 3.8% achieved in 2017. Alternatively, in North America, manufacturing production has experienced considerable growth. Manufacturing production has grown

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in the United States from 1.8% in 2017 to 3.1% in 2018. However, in Europe, the growth rate of the manufacturing sector has decreased from 3.5% to 2.6%. Moreover, in East Asia, manufacturing growth decreased from 3.1% to 1.9% [2]. In March 2020, manufacturing production decreased to 32.2% in Perú owing to the low production rates caused by lockdown [3].

Within the metalworking industry, companies must operate at large capacities; otherwise, they will not be able to satisfy the market demand if they lack good production control and management. Because of such a situation, these companies generate less revenue, eventually fading into the market. This occurrence is largely attributed to poor business management practices at MSME levels coupled with little market acumen, inadequate internal organization, and a lack of production planning [4]. A study conducted by the Peruvian Ministry of Economy and Finance identified the factors causing low productivity in Peruvian MSMEs. The main factors include poor employee training, a lack of investment in specialized training, limited access to capital, and little use of modern business practices by micro and small entrepreneurs [5].

2 State of the Art

2.1 Current Production Management in MSMEs

The contributions of MSMEs to the world are clear to everyone because they play an important role in the global economic systems, accounting for 88%–90% in national economies, indicating a significant impact on the national GDP [6, 7]. Current business management models focus on production development, which mainly assesses production activities. However, this approach fails to address production processes that are limited by poor management and resource availability, thus inducing economic losses and permanent closures of economic activities. In this context, research results have revealed that small- and medium-sized companies can become operationally solvent if they adopt management methods and tools supporting productivity and agility [7, 8].

2.2 Lean Manufacturing for the Production Management of MSMEs

Some researchers agree that the lean approach offers high operational potential. Moreover, its methods and tools can be used to streamline production efficiencies, exerting a significant impact on production volumes and maximizing its profitability. Hence, some studies seek to maximize productivity by 20% and reduce production costs [8, 9]. These data are obtained from a study that realized an average saving of $50,000 using lean manufacturing methodology [9, 10].

2.3 Agile and Lean Methodologies for Production Management in MSMEs

Because there is a considerable disagreement in the literature regarding whether these two strategies are mutually supportive or mutually exclusive, the research initiative is not very well defined. However, research has been conducted to verify the impact of using lean and agile practices to provide evaluation criteria regarding their use in project

work. The process of combining both approaches did not yield the expected results owing to a lack of information on simultaneously implementing both approaches to improve productivity and teamwork. Considering this situation, further research proposals are required to encourage the implementation of both approaches [11, 12].

3 Contribution

3.1 Proposed Model

The design and implementation of a production management model using agile and lean manufacturing approaches are divided into four stages. These stages allow the organization of all production actors to adopt a new pace of work. This approach yields faster and more efficient processes, thereby increasing the production level, reducing operating costs, and meeting market demands.

- Planning Initiatives: In this first stage, it is possible to understand the current situation of the company with respect to its competitive environment. The strategic direction of the organization can also be performed along with the planning of implementing a new model that must be communicated to all personnel involved in the production area.
- Support System Development: In the second stage, collaborators coordinate and are trained on lean manufacturing and agile methodologies. Finally, they begin designing the project under these tools.
- Improvement Execution: In the third stage, the implementation of lean manufacturing tools is performed based on an agile approach such as the scrum by conducting three 4-week sprints and daily 30-min scrum meetings.
- Monitoring and Control: Finally, monitoring and control key indicators facilitate the adoption of good production practices by standardizing processes, all aimed at promoting and building a lean culture in the organization (Fig. 1).

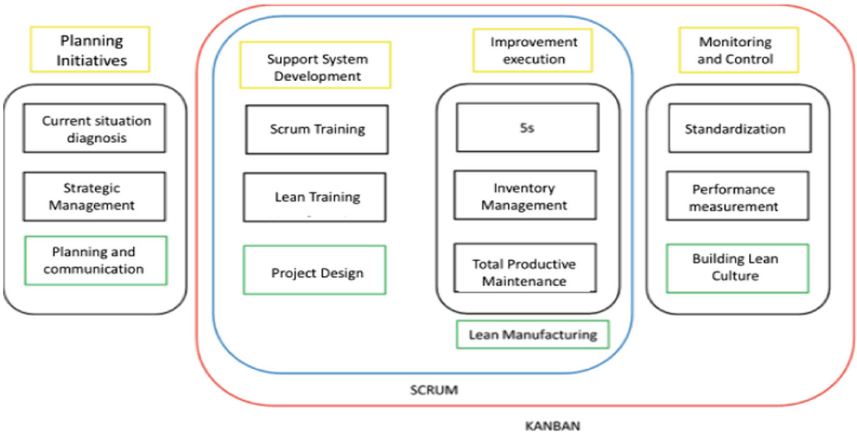

Fig. 1. Production management process

Figure 2 shows the proposed production management model and its stages. This model improves productivity and increases production levels and sales in Peruvian metalworking MSMEs.

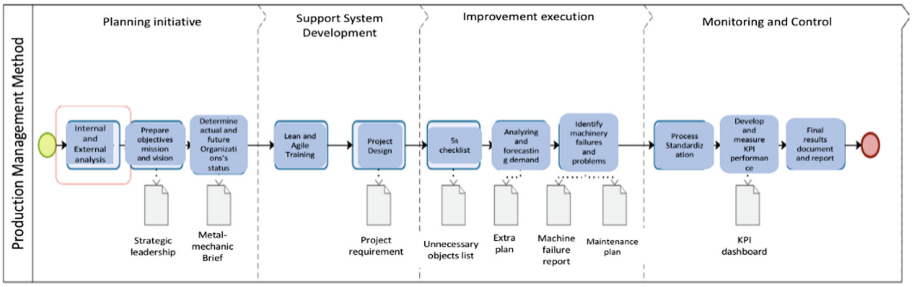

Fig. 2. Production management method

3.2 Process

To appropriately implement the proposed method, an industry assessment must be conducted to better understand its current situation, ways to adopt new tools or technologies available in the market, and determine competing companies. Simultaneously, an internal assessment of the organization must be conducted to verify processes, sales, and personnel. Then, a report is generated based on the current situation of the company.

Thereafter, the description of the objectives and the mission and vision are prepared to engage the strategic leadership of the company and identify the main problem affecting its productivity. Finally, the future state of the company is determined using the metalworking brief.

In the support system development stage, scrum and lean manufacturing training sessions are organized for the production area. In these sessions, a lean manufacturing project will be developed based on an agile approach after identifying the minimum requirements for its development.

In the improvement execution stage, the requirements provided by the metalworking brief and product backlog are developed for each scrum sprint. They are determined for each tool used to improve and standardize all processes that are beneficial for production management. First, a 5S checklist is prepared. Based on this checklist, all unnecessary items and activities are removed. Additionally, this tool is used to standardize activities and discipline operators. In the second sprint, inventory management is established, including analyzing and forecasting the demand to obtain an aggregated plan for the organization. Finally, the total production maintenance tool is used to identify failures and problems in machinery, generating a failure report for each machine. Later, a preventive maintenance plan is prepared.

Finally, in the monitoring and control stage, each tool is assessed based on its respective indicators. If there is an improvement, the obtained results obtained are documented and recorded. If there is no improvement, the project design is re-established.

3.3 Indicators

Production management indicators are used to measure model implementation. These indicators measure and assess the success rate of the production management model implemented in the company.

Damaged Finished Products (5S): This indicator specifies how many products have been damaged within the work area.

$$Total\ Damaged\ Products = \frac{Damaged\ products}{Total\ products} \tag{1}$$

Cycle Time (5S): This indicator is assessed considering process times, and the results are displayed in a traffic light assessment dashboard.

Unfulfilled Orders due to Shortages (Inventory Management): This indicator specifies the number of orders that has been rejected or canceled owing to inventory shortages.

$$Nonfulfillment = \frac{Rejected\ orders}{Total\ orders} \tag{2}$$

Number of Stoppages (TPM): An annual control of stoppages will be conducted for each failure in any production machine.

OEE Machines (TPM): This indicator specifies the efficiency of production machines.

$$OEE = Availability \times Performance \times Quality \tag{3}$$

Productivity: This indicator specifies the number of finished goods in store without any failure or defect.

$$Productivity = \frac{(Amount\ of\ Total\ Orders\ Stored)}{Total\ Production} \tag{4}$$

4 Validation

4.1 Simulation

Scenario. Distribution compiled by Input Analyzer. The information is compiled based on the time spent by each process: arrival, lathe, sanding, riveting, and finishing. The simulation is performed based on the current company production flows, simulating 450 runs in a period of one month of production.

Initial Diagnosis. After validation, initial diagnosis based on previous studies is reported as the basis for subsequent analysis (Tables 1 and 2).

Table 1. Average time

	Traffic Light			Current Situation	5S	Inventories Management	TPM	Proposed Model
Time	>17min	14-17min	<14 min	17.34	14.79	15	16	14.7

Table 2. Noncompliance and productivity percentages

	Traffic Light			Current Situation	5S	Inventories Management	TPM	Proposed Model
Non-compilance%	>12%	5%-12%	<5%	66.68%	19%	16%	22%	12%
Productivity%	<60%	61%-85%	>85%	33.32%	81%	84%	78%	88%

Validation Design. The production process simulation is conducted. Obtained results (Tables 3 and 4):

Table 3. Obtained results: time

	Traffic Light			Current Situation	5S	Inventories Management	TPM	Proposed Model
Time	>17min	14-17min	<14 min	17.34	14.8	16.47	16.53	14.5

Table 4. Obtained results: noncompliance and productivity

	Traffic Light			Current Situation	5S	Inventories Management	TPM	Proposed Model
Non-compilance%	>12%	5%-12%	<5%	66.68%	65.46%	44.27%	63.03%	36.42%
Productivity%	<60%	61%-85%	>85%	33.32%	34.54%	55.73%	36.97%	63.58%

4.2 Three Scenarios

Scenario. The process works based on three possible scenarios: optimistic, neutral, and pessimistic. Results are highlighted based on the outlook and possible probabilities for each scenario evaluated. Templates are used as an assessment method to assess the impact generated using the proposed model.

Initial Diagnosis. The base diagnosis of previous studies is established to perform the assessment after the development of the validation and its results (Table 5).

Table 5. Average result table

		Traffic Light			Optimist	Neutral	Pesimist	Current Situation
5S	Damaged Finished Goods%	>5%	2%-5%	<4%	2%	4%	15%	8.04%
TPM	OEE	<65%	65%-80%	>80%	91%	65%	25%	54.74%
Inventories Management	Stoppage per year	>55	30-55	<30	18	80	140	70
	Shortage due to non-compliance%	>12%	5%-12%	<5%	1%	6%	15%	5%

Validation Design

5S METHODOLOGY. First, we introduce the employed 5S template. Following the established contribution process, this template assesses the results obtained based on its application and correlates them based on the percentage of damaged finished goods (Table 6).

Table 6. Correlation results

Assessment	20–35	36–75	76–100
Damaged finished goods %	>5%	2%–5%	<4%

TPM METHODOLOGY. Once the application process is completed, the efficiency of the equipment is evaluated based on the obtained results using the OEE indicator. Later, machine stoppages are also assessed based on the information provided by the template (Table 7).

Table 7. OEE Evaluation Criteria and Amount of Stoppage: Results

OEE Evaluation Criteria		
<65%	65%–80%	>80%

Amount of Stoppage: Results		
>55	30–55	<30

INVENTORY MANAGEMENT METHODOLOGY. The total projected production of 8,751 pots is considered as a reference. The percentage is obtained by dividing the unfulfilled orders by the total production. Finally, the results are obtained as follows (Table 8):

Table 8. Results obtained

SCENARIO	5S METHODOLOGY	RESULTS	TPM	RESULTS	INVENTORY MANAGEMENT	RESULTS
OPTIMIST	Damaged finished goods %	4%	Macchine Stoppage per Year - OEE	91% 18	Non-compliance due to shortage %	1%
NEUTRAL	Damaged finished goods %	3%	Macchine Stoppage per Year - OEE	66% 90	Non-compliance due to shortage %	5.21%
PESIMISTIC	Damaged finished goods %	11%	Macchine Stoppage per Year - OEE	30% 138	Non-compliance due to shortage %	13.36%
ACTUAL	Damaged finished goods %	8.04%	Macchine Stoppage per Year - OEE	54.74% 70	Non-compliance due to shortage %	5%

5 Conclusions

This research combined both the concepts of agile and lean methodologies with existing production management methods and models to develop a production management method based on an agile approach for MSMEs. Data were collected from a Peruvian metalworking company to simulate the proposed method using the Arena simulator and scenario analysis methodologies, which provided a general overview of the implementation. However, we suggest directly adopting the production management method and implementing it in companies to measure the performance and efficiency levels of their production areas.

According to the results obtained based on the validation of the proposed method, to guarantee a successful implementation in manufacturing companies, we suggest the following:

- The production management method must be used as a basis for organizations because the project design phase largely depends on the results obtained from the current situation assessment of each organization. Therefore, this assessment must be objective and focus on improving their production processes.

- Full commitment from senior management is critical because they lead the production teams in MSMEs. For this reason, they must be engaged from the beginning and convinced that the production management method will have a positive impact on their organizations.
- The optimization of raw material and available operational resources is vital to achieve the ultimate goal of the proposed method: securing high production levels and effectively fulfilling a high percentage of customer orders.

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