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Original Article

Design and Implementation of a Management Model with a Focus on the Operator to Improve Productivity in the Steel Industry

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Abstract - *The objective was to apply Operator-Centered Management (OCM) to increase production capacity in the steel industry, whose main activity is steel production, by implementing Lean Manufacturing tools to optimize its processes. Among these tools, the fishbone diagram allowed us to understand and analyze the key factors influencing the lack of process standardization among production personnel. Furthermore, the 5S methodology contributed to improving the organizational climate, while Autonomous Maintenance (AMM) was used to increase equipment efficiency. The research was conducted using quantitative methodology, a pre-experimental design, and an explanatory scope. The sample, composed of 251 employees, was selected using probability convenience sampling. Due to the applied and exploratory nature of the research, it focuses on understanding operator perceptions, practices, and experiences within the industrial environment. As a result, a significant increase in the organization's productivity level was evident, rising from 46.62% to 77.49%.*

Keywords - *Empowerment, Lean manufacturing, Improvement plan, Productivity, 5S.*

1. Introduction

According to the authors [1, 23], in the contemporary business environment, productivity is an essential element for achieving success and maintaining competitiveness. Organizations are constantly forced to optimize their resources, processes, and human capital in order to achieve their strategic goals. The largest net imports come from countries in the rest of Asia, Africa, the Middle East, and the United States. As for Latin America, the region's trade balance in the steel sector is practically balanced, with a slight surplus. However, according to the authors [2, 3], in the context of international trade, it is relevant to differentiate Latin American steel exports between those products that belong to an initial stage of processing - such as slabs, billets and blooms - and products with a higher degree of processing, such as long rolled products, flat rolled products and tubes. Furthermore, according to [4, 8], in Latin America, 72.5% of production is in the hands of the five largest companies, which shows a degree of concentration similar to that observed at the global level, considering the respective production volumes. This trend towards greater concentration has been driven by mergers and acquisitions, which, although historically present, have intensified in recent years. In this context, the total value of these transactions has increased significantly, reflecting the dynamics of the market and the sector's economy.

At the national level, the Peruvian Ministry of Tourism points out that the reduction and even total elimination of tariffs has not favored the national industry or consumers; on the contrary, it has generated a situation of lack of protection for the local industrial sector. According to the author [5, 9], the State promoted this tariff policy under the argument of facilitating the entry of inputs for production. Peru's productivity landscape exhibits a persistent mix of sectoral strengths and structural weaknesses: while mining and some export-related activities maintain relatively high productivity levels, driving macroeconomic growth, aggregate labor productivity has recently declined, reflecting employment growth that has not been accompanied by greater productivity gains per worker. At the same time, high labor informality with rates among the highest in the region and barriers to access to financing and innovation limit the scale and modernization of micro and small enterprises, hindering the diffusion of technology and management practices that boost productivity. According to authors [6, 7], leaders, at some point, have had to face the need to manage change in a planned manner. However, it is recognized that designing a change in theory and achieving its effective implementation are two very different processes; generally, planning is much easier than carrying out the change. This is because people often behave differently from what is expected, even though following written guidelines would be a simpler approach. Locally, one of the largest plants located on the coast of the country has a plant dedicated to pipe manufacturing, where square and round electrowelded pipes of various thicknesses are produced. Currently, Siderperú supplies only 33% of the domestic market with 2,000 tons per month, a significant drop from the 80% it had previously, affected by several factors, among them, the price of its pipes, which is higher than that of its competitors: 4% more expensive than Aceros Arequipa, 8% more than pipes imported from Ecuador and 10% more than pipes imported from China. Likewise [10], with the opening of the FTA, imports in the steel industry have increased exponentially.

The main players are the Chinese, Indian, Turkish, and Ecuadorian industries. Keeping the import price at 0% tariffs definitely makes the Peruvian market attractive. Although Siderperu has invested USD 220 million in the modernization of its industrial complex, and Aceros Arequipa inaugurated its new rolling mill in 2013, it is complicated to compete with imports, which have much more advanced levels of automation with a lower operating cost. Unplanned plant outages are increasing as a result of a poorly defined maintenance plan.

However, the authors [12] point out that the number of lost-time accidents per year is due to various factors, such as lack of leadership, lack of motivation, and lack of teamwork, generating negative consequences that transcend the work environment, such as loss of limbs and even prolonged breaks. Despite the extensive literature on management models and industrial productivity [11], there is a significant lack of studies that address the implementation of operator-centered management models in the specific context of the steel industry. Most research prioritizes technological approaches, automation, or process efficiency, leaving aside the active role of the operator as an agent of continuous improvement. This gap limits the development of comprehensive strategies that integrate human capabilities with production systems to achieve sustained improvements in productivity.

The main question of this study is:

To what degree could the implementation of the Operator Focused Management model contribute to improving productivity? This leads to the following specific questions:

To what extent can the implementation of the Operator Focused Management model increase efficiency in the steel sector?

To what extent can this model optimize the efficiency of the steel industry processes? The answers to these questions will facilitate the evaluation of the feasibility and advantages of the design and implementation of Operator Focused Management.

2. State of the Art

The authors highlight the importance of productivity and management in Peru's agricultural sector, focusing specifically on asparagus packaging. To address the main challenges related to low productivity, a model was designed that incorporates autonomous and preventive maintenance practices. A pilot project was implemented with the aim of reducing unplanned downtime and applying work standards that eliminate inefficiencies. The model was validated using a sample of 72.98 kg of asparagus, analyzing the processing times for each task as input data. This model, evaluated using Arena software, showed a 21% increase in packaging productivity, a 36 kg/man-hour improvement in labor performance, and a 26.35% increase in equipment availability. The results offer a replicable model for medium-sized agro-export companies, helping them to optimize their operational efficiency and strengthen their position in international markets. In addition, the research contributes to the limited body of literature on the use of Lean and TPM methodologies in agricultural processes, demonstrating their usefulness in reducing productivity gaps in developing economies.

Similarly, another recent study [13] highlights the importance of productivity and management in any type of company, given their direct impact on profitability. Increasing equipment availability can translate into a significant improvement in productivity. By reducing failures or breakdowns, equipment uptime is increased, which directly contributes to higher performance. In this context, the main objective of the study was to reduce the downtime of the rolling mill and improve the operational availability of the machinery. As a result, Overall Equipment Efficiency (OEE) increased significantly, from 56.42% to 73.52%, representing an improvement of 30.30%. This positive development is mainly due to the reduction in section changeover time and a lower frequency of failures.

In the research carried out by the authors [14], the objective was to increase the operational efficiency of an SME in the automotive sector in Indonesia through the implementation of Total Productive Maintenance (TPM) in the blow molding machines located in Plant 7 of RMA Ltd. The results showed an improvement in Overall Equipment Effectiveness (OEE), which rose from 67.42% to 77.80%, thanks to advances in availability, performance, and quality. In addition, a significant reduction in the main sources of loss was achieved, demonstrating the effectiveness of measures such as the dissemination of the TPM approach and the application of proactive maintenance, offering a replicable model for other small and medium-sized enterprises in the automotive sector.

However, the authors [15] emphasize that management plays a key role in lean manufacturing, understood as a business strategy aimed at the continuous improvement of all production processes, with the goal of reducing both waste and costs. The implementation of this approach necessarily begins within the existing design of the facilities. In this study, lean methodologies were integrated with plant design planning techniques to optimize factory performance, applying the 5S tool together with a structured design to reorganize the layout of the machines, eliminating waste generated by unnecessary movements.

As a result, process efficiency increased from 53% to 66% when comparing the two proposed distribution alternatives. Bridging the gap in the adoption of efficient production and optimal use of space is a key factor in achieving long-term industrial sustainability.

Similarly, the authors highlight lean manufacturing in the metal production chain for air conditioning systems. The methodology was developed in two phases. In the first phase, a detailed presentation of the company was made, including a description of its current operation, organizational structure, products, and work plan, in addition to identifying the main existing deficiencies. During the second phase, a strategy was designed using lean manufacturing tools in order to address previously detected improvement opportunities. The application of these tools allowed us to optimize the use of space by 64%, 80%, 71% and 50% in the measuring, cutting, bending, and welding areas, respectively, while achieving significant improvements in production times. From these results, it is concluded that the adoption of lean manufacturing brought significant benefits to the company, considerably improving both its production process and work environment.

3. Objectives

3.1. Main Objective

The main objective is to determine to what extent changing the current management to Operator Focused Management will improve productivity.

3.2. Secondary Objectives

Determine to what extent the design and implementation of Operator Focused Management can improve efficiency in the Steel Mill.

4. Materials and Methods

The document points out that the experimental design is distinguished by meeting two essential conditions to ensure experimental control and internal validity: management of the independent variable and uniformity between groups both before and after applying the experimental treatment.

For this research, a pre-experimental cross-sectional design will be used to evaluate the real impact of the design and development of the Operator Focused System. This methodology is suitable for an explanatory study, since its main objective is to compare the productivity in decision-making before and after implementing the system. Likewise, a quantitative approach is adopted in the study, with the purpose of collecting and analyzing quantifiable data in order to answer research queries or test hypotheses. On the other hand, according to [16], information on the variables of interest was collected for analysis.

In particular, both an initial test and a final test were used to evaluate the implementation of Operator Focused Management on productivity in the steel industry. The population consisted of the employees of a steel company in the years 2023 for the pre-test and 2024 for the post-test; in both cases, the number of employees was 722.

Inclusion Criteria: All employees who worked in the years 2023 and 2024.

Exclusion Criteria: The number of employees who worked before 2023 and after 2024 is excluded.

The sample was calculated using the simple random sampling formula for finite populations, applied to the entire company, which has 722 employees. This will allow us to identify the cell to be analyzed.

Sampling for the present study is probabilistic for a finite population.

Where:

n = Sample size
N = Population = 722 employees
Confidence level 95% z = 1.96
e = Margin of Error = 5%
p = Probability of occurrence of the event = 50%.

$$n = \frac{\frac{z^2 \ x \ p(1-p)}{e^2}}{1+\frac{z^2 \ x \ p(1-p)}{e^2 \ N}}$$

An

n = 251 employees were obtained.

Then, the cell whose number of collaborators is closest to the sample number obtained as a result of the calculation was taken as a sample. In this case, it corresponds to the tube cell, which in turn is the cell with the highest number of collaborators.

Throughout the research process, the observation technique was used as a tool to collect information that would allow a holistic understanding of the variables analyzed and their indicators defined in Table 1: “Percentage of efficiency” and “Percentage of effectiveness”. These techniques represent the general basis for data collection and are essential for obtaining accurate and relevant information.

Table 1. Indicators, techniques, and instruments

Indicator	Technique	Instrument
Efficiency Percentage	Observation	Observation Form
Percentage of Effectiveness	Observation	Observation Form

5. Solution Implementation

The following Phases were elaborated for the Operator Focused Management Design: (A) Diagnosis of the Current Situation, (B) Design of the Management Model, (C) Pilot Implementation, (D) Evaluation of Results, (E) Scaling and Operational Standard. Below is the schedule for Operator-Focused Management (See Table 2).

Table 2. Schedule for operator-focused management

Phase/Activity	Descripción	Estimated Duration	Responsables
Preparation and Diagnosis	- Identification of critical areas. - Benchmarking visits to leading companies. - Raising awareness about the need for change. - Definition of initial indicators.	2 Months	Senior Management / Implementation Committee HR / Production Management Facilitators / HR Facilitators / Operators
Organizational Design	- Definition of the cell structure. - Assignment of facilitators and leaders. - Definition of roles and responsibilities. - Alignment with labor policies and local culture.	1 Months	Implementation Committee / Area Managers Senior Management / Implementation Committee HR / Production Management Facilitators / HR
Training and Communication	- Leadership, motivation, and cell-based training. - Internal communication about GFO objectives. - Development of training matrices by role.	2 Months	Facilitators / Operators Senior Management / Implementation Committee
Pilot Implementation in Cells	- Recruitment and selection of operators. - Critical training and process standardization. - Execution according to standards. - Initiation of results-based meetings.	2 Months	HR / Production Management Facilitators / HR Facilitators / Operators
System Consolidation	- Performance evaluation and recognition. - Implementation of variable compensation linked to results. - Audit of standards. - Fault handling and feedback.	2 Months	Senior Management / Implementation Committee
Evaluation and Continuous Improvement	- Measurement of results (costs, productivity, safety, work environment). - System adjustments. - Dissemination of best practices. - Expansion of the GFO to more areas.	3 Months	Alta Dirección / Comité de Calidad

5.1. Phase 1- Diagnosis of the Current Situation

An Ishikawa diagram (see Figure 1) will be developed to identify and organize the factors that are most related to the problem. Table 3 reveals that the main opportunities for organizational improvement include the absence of a continuous improvement system, limited collaboration of team members, deficiencies in cleanliness and order, and deficiencies in preventive maintenance. Productivity-related factors were also identified as constituting 58% of the problems. Consequently, taking these aspects into account, the lean manufacturing tool selected to address these difficulties was Operator-Focused Management. Before proceeding with the implementation, a check sheet was designed to record activities, production, and operating costs.

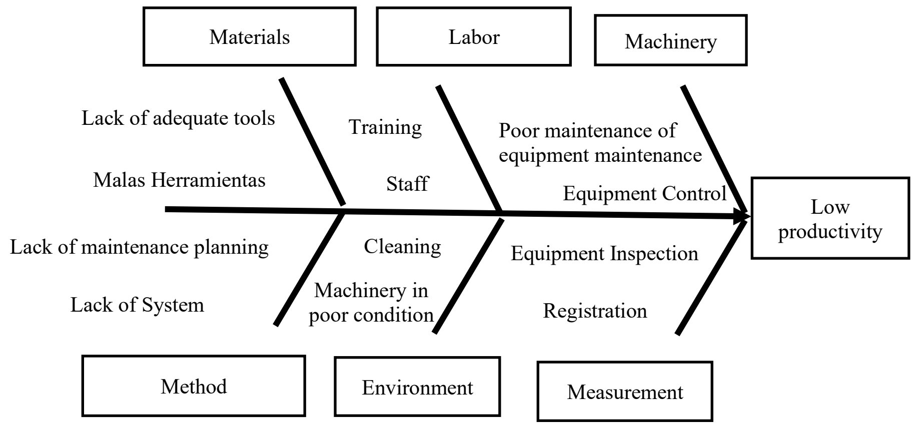


Fig. 1 Ishikawa diagram of low productivity

Table 3. Frecuencia de factores de baja productividad

No.	Problems	Frequency	Percentage (%)
1	Lack of a continuous improvement system	70	20%
2	Lack of teamwork	50	34%
3	Lack of Cleanliness and Order	45	47%
4	Preventive Maintenance Deficiency	40	58%
5	Deficiency in the inventory order	35	68%
6	Raw material waste	30	77%
7	Lack of staff training	25	84%
8	Absence of Supervision	20	89%
9	Use of obsolete equipment	17	94%
10	Lack of work motivation	12	98%
11	No noise control	8	100%

5.1.1. GFO

Operator Focused Management is a continuous improvement management system that seeks to focus the action on the operator, empowering them in different systems such as Safety, 5S, Environment, TPM, Production, Fault Treatment, and Costs. GFO facilitates achieving and maintaining a competitive advantage by synchronizing human capital, operational processes, and technology with corporate strategy.

5.2. Phase 2 - Design of the Management Model

Cell work is based on taking advantage of human skills, promoting personal development and self-realization. It is made up of stable groups that assume responsibility for a product or part of the process, with commitment to results and focus on the internal customer.

5.2.1. Stages of Cell Work

There are external factors that directly impact productivity that the GFO seeks to address in the cell, consisting of six stages: training, communication, compensation, recognition, performance evaluation, and critical coaching (See Figure 2).

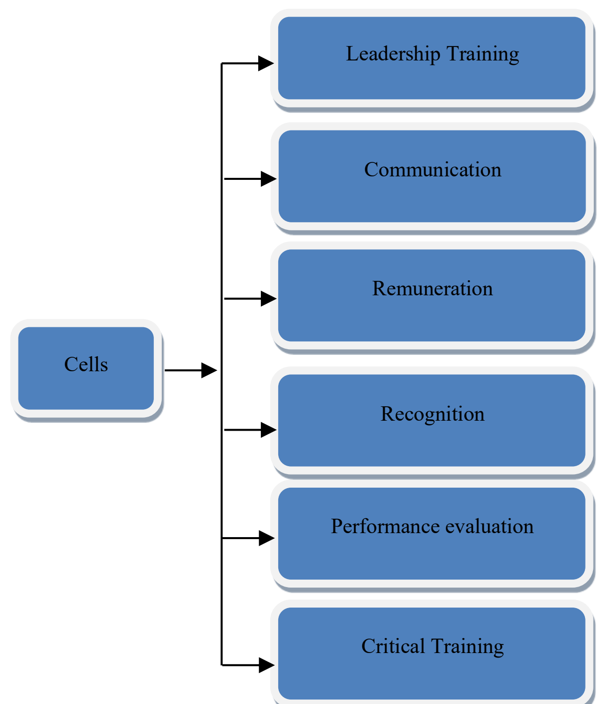


Fig. 2 Cell work stages

Likewise, in terms of Organizational Structure and Cell Definition, an organizational structure was defined in line with the GFO and existing models, taking into account contracts, culture, and local legislation. Processes and personnel were analyzed to identify productivity opportunities.

Each cell will have its own cost center, with a maximum of 40 employees per facilitator. In addition, during this stage, the roles and responsibilities of the cell were defined, skill requirements were aligned, and positions, selection criteria, and the integration program were evaluated and adjusted to the new functions.

Finally, through the Training Matrix, the training matrices were updated to reflect the new roles, and specific training was planned, prioritizing real needs over existing documentation.

5.3. Phase 3 - Pilot Implementation

Regarding Leader and Team Training, the instructors (Leaders) were prepared in the training materials, including concepts, on-site practices, and simulations, to guarantee the instructors' capacity. The Leader conducted the training together with his team. All collaborators were trained according to Table 4. Also, the indicators were broken down according to Table 4, in order to correctly establish goals for the various organizational levels.

Table 4. Operator focused management - people (2023)

<table>
<tr><th colspan="2" rowspan="2">PROFILE</th><th colspan="2">OPERATION</th><th>MANTTO</th><th>RESPONSIBLE FOR SUPPORT AND GUIDANCE</th></tr>
<tr><td colspan="2">Potential to learn, Willingness to learn, Teamwork.</td><td colspan="2">Initiative, Committed, Technical Proficiency</td></tr>
<tr><td rowspan="8">PROCEDURES</td><td>Education</td><td>Secondary Complete</td><td>Technicians</td><td>Technicians</td><td>Specialized Technicians</td></tr>
<tr><td rowspan="3">Integration</td><td colspan="3">General</td><td rowspan="3">Facilitator</td></tr>
<tr><td colspan="3">Area Specification (50% on the job)</td></tr>
<tr><td colspan="3">Specification per cell (100% at Work)</td></tr>
<tr><td rowspan="4">Process, Operation, and Maintenance.</td><td colspan="3">Notions of the Iron and Steel Industry</td><td>Facilitator / External</td></tr>
<tr><td colspan="3">Specialization According to Position</td><td rowspan="3">Operators</td></tr>
<tr><td colspan="3">Specialization according to Foundry - Critical Tasks</td></tr>
<tr><td colspan="3">Operating Standards, Routine Standards, Total Quality in the Workplace.</td></tr>
</table>

According to the author [17], by knowing all the variables that impact the results of a certain indicator (its unfolding), it is possible to identify precisely the tangible challenges to improve the process. Similarly, the authors [18] stated that the indicators established should contemplate the five fundamental aspects of quality: Health and Safety, Product Quality, Environment, Costs, and Compliance in delivery, as well as considering the stakeholders, which include Customers, Teams, Community, and Suppliers.

Table 5. Tubing Cell Indicator Splits (2023)

<table>
<tr><th colspan="4">Tube Cell</th></tr>
<tr><td rowspan="3">Security</td><td>1</td><td>No. CPT Accidents</td><td>No.</td></tr>
<tr><td>2</td><td>No. Accidents SPT</td><td>No.</td></tr>
<tr><td>3</td><td>No. Incidents, Acts, and Substandard Conditions</td><td>No.</td></tr>
<tr><td rowspan="6">Process</td><td>4</td><td>5S</td><td>%</td></tr>
<tr><td>5</td><td>Cost of specific materials</td><td>USD/t</td></tr>
<tr><td>6</td><td>Usage</td><td>%</td></tr>
<tr><td>7</td><td>Metallic losses</td><td>Kg/t</td></tr>
<tr><td>8</td><td>Production</td><td>t</td></tr>
<tr><td>9</td><td>Compliance with the production program</td><td>%</td></tr>
</table>

On the other hand, the authors [19] created a diagram that represents the business in an integral way, including suppliers, inputs, people, processes, tools, products, customers, verifications, and indicators. This is used to integrate new collaborators and as a basis for defining the business of each area.

Likewise, the authors [20] elaborated an Integrated Process Mapping, which documents the knowledge of the process, integrating customer requirements and tasks related to safety, environment, quality, maintenance, and production. Finally, critical tasks in the process were identified in order to focus efforts on their improvement, implementing a standard procedure for pipe manufacturing.

5.4. Phase 4 - Evaluation of Results

It consisted of the management of Routine Indicators, whose objective is to ensure that the results already obtained are maintained. During this stage, a meeting system will be developed to ensure the management of improvement and routine activities. Roles and responsibilities were defined for acting in normal and/or abnormal situations. Agendas were developed for the Plant Manager, Area Managers, and Facilitators (See Table 5).

Table 6. Frequency of results meetings (2023)

Item	Description	Frequency of Meetings
1	Cell Meetings with Facilitator	Weekly
2	Multiplier Meetings with Facilitator	Fortnightly
3	Facilitator Meetings with Management	Weekly
4	Routine Facilitators' Meeting	Weekly

5.5. Phase 5- Scaling and Operational Standards

This step focused on developing Standards for Critical Tasks (Daily Use Routine Management) to maintain results that are certain and predictable, ensuring the results of repetitive operations by reducing variation. The objective of this step was to document process knowledge, integrate safety, quality, cost, delivery, and environmental practices, identify, develop, maintain, and systematically review standards (See Table 7). For Critical Training, employees requiring training were identified, and the corresponding standards were defined. Their knowledge of processes and equipment was updated, establishing a structured training plan.

Table 7. Standardization map (2023)

STANDARDIZATION MAP								
ITEM	PROCESS	CRITICAL TASKS	Existing Standards			Action (Yes/No)		
			PTUB P /PR	PTUB I /EO	ULTIMA VERSION	CREAR ESTANDAR	PR	EO
1	PIPES	Pipe and Profile Manufacturing Process	YES		Oct 2023	YES	PR-750-001	YES
2	PIPES	Color coding standard		YES	Oct 2023	YES	EO-750-001	YES

Likewise, execution according to standards reinforced the importance of following rules to ensure stable results and reduce variations in repetitive operations, motivating operators to comply with them. Through failure analysis, operators, maintenance personnel, and operations personnel were involved in the analysis and resolution of failures, establishing mechanisms that promote a favorable environment for addressing them effectively.

Finally, a Standards Audit was conducted, standardizing critical tasks, ensuring that all employees follow the standards. Potential failures and opportunities for improvement were identified to maintain the stability of the process (See Table 8).

Table 8. Annual audit schedule (2023)

EQUIP	SELF ASSESMENT			ASSESMENT		
	ENE	MAR	MAY	JUL	SET	NOV
M2	X			X		
TMC		X			X	
M2.5			X			X

6. Results

6.1. About Expert Validation

The tools used for data collection showed reliability as they were chosen from reliable sources, such as the SAP system and production reports, in relation to the independent variable associated with Operator Focused Management. In relation to the dependent variable, focused instruments were used to measure rigorously by experts, see Table 9.

Table 9. Validity indicators

Indicator	Score		
	Expert 1	Expert 2	Expert 3
Clarity	85%	80%	90%
Objectivity	80%	80%	85%
Currentness	90%	85%	90%
Organization	85%	85%	85%
Sufficiency	95%	90%	95%
Intentionality	100%	90%	85%
Consistency	100%	90%	90%
Coherence	90%	85%	90%
Methodology	80%	80%	90%
Relevance	85%	81%	86%

6.2. Descriptive Analysis

Table 7 clearly shows the improvement in the degree of compliance with the Operator Focused Management System during the transition from pre-test to post-test after its implementation. In 2023, compliance was 20%, but after implementing the Operator Focused Management System, there was a notable increase, reaching 94% in 2024. There is a clear trend towards continuous improvement (see Tables 10 and 11).

Table 10. Check sheet before implementation of operator focused management (2023)

	Evaluator: Juan Calderón			**Period 2023**		
	Initial Qualification 13/64					
	Evaluation Criteria 0=Bad, 1=Regular, 2=Acceptable, 3=Good, 4=Excellent					
No.	Detail	0	1	2	3	4
1	Training		X			
2	Organizational Structure / Cell Definition		X			
3	Profile Service		X			

4	Roles and Responsibilities of Facilitators		X			
5	Roles and Responsibilities of Managers and Directors	X				
6	Indicator Implementation and Business Definition		X			
7	Process Mapping		X			
8	Control analysis of critical process parameters and definition of critical task analysis.	X				
9	Involvement		X			
10	Failure Analysis		X			
11	Standards Audit		X			
12	Stable Results		X			
13	Implementation of the 4 critical GBS processes and Tools/Systems to be delegated to the multipliers.	X				
14	Profiling, Selection, and Rotation of Multipliers		X			
15	Autonomy and Recognition of Multipliers		X			
16	Processes of follow-up and coaching of multipliers		X			
SUBTOTAL		0	13	0	0	0
TOTAL		13/64				

Table 11 shows that the percentage of compliance with the Operator Focused Management started at 20%, which reflects the low motivation of the operators. Once the Operator Focused Management has been implemented in production, it is essential to find the actual productivity in order to demonstrate the improvements achieved (see Table 12). Table 13 shows that the verification yielded a compliance level of 94%, which indicates that Operator Focused Management contributes to improving plant management.

Table 11. Level of compliance with operator focus management (before implimentation)

DETAIL	Score Achieved	Target Score	Compliance (%)
BEFORE THE START OF GFO - 2023	13	64	20%

Table 12. Post implementation of operator focused management check sheet (2024)

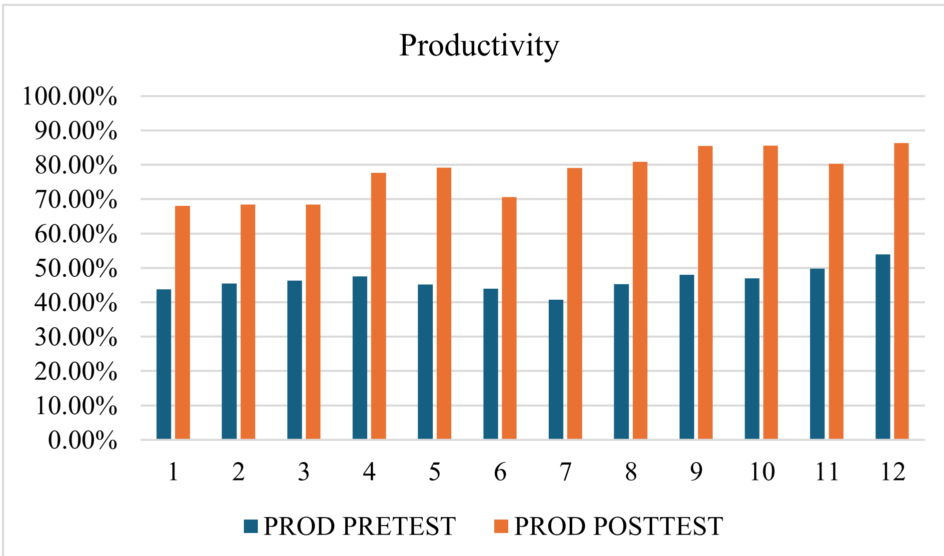
	Evaluator: Juan Calderón				**Period 2024**	
	Initial Qualification 60/64					
	Evaluation Criteria 0=Bad, 1=Regular, 2=Acceptable, 3=Good, 4=Excellent					
No.	Detail	0	1	2	3	4
1	Training				X	
2	Organizational Structure / Cell Definition					X
3	Profile Service					X
4	Roles and Responsibilities of Facilitators					X
5	Roles and Responsibilities of Managers and Directors					X
6	Indicator Implementation and Business Definition				X	
7	Process Mapping					X
8	Control analysis of critical process parameters and definition of critical task analysis.					X
9	Involvement					X
10	Failure Analysis					X
11	Standards Audit				X	
12	Stable Results				X	
13	Implementation of the 4 critical GBS processes and Tools/Systems to be delegated to the multipliers.					X
14	Profiling, Selection, and Rotation of Multipliers					X
15	Autonomy and Recognition of Multipliers					X
16	Autonomy and Recognition of Multipliers					X
SUBTOTAL		0	0	0	12	48
TOTAL		60/64				

Table 13. Level of compliance with operator focus management (after implimentation)

Detail	Score Achieved	Target Score	Compliance (%)
One Year After Implementation	60	64	94%

6.3. Variable Productivity

Figure 3 shows that, during the year 2023, the average productivity registered 46.42%. In contrast, during the subsequent evaluation carried out in 2024, the average was 77.49%, reflecting a significant increase of 31.07% between the two periods analyzed. These data clearly indicate that the design and implementation of Operator Focused Management has had a positive effect on productivity.As evidenced in Table 14, post-implementation, the productivity variable experiences a significant increase. In 2023, the mean increased from 46.41 to 77.49, while the median increased from 45.91 to 79.13, reflecting an average improvement in productivity after the intervention.



DETALLE	1	2	3	4	5	6	7	8	9	10	11	12
PRETEST	44%	45%	46%	48%	45%	44%	41%	45%	48%	47%	50%	54%
POSTTEST	68%	68%	68%	78%	79%	71%	79%	81%	85%	86%	80%	86%

Fig. 3 Descriptive analysis of the pre-test (12 months of the year 2023) and post-test (12 months of the year 2024) of the variable Productivity

The mode increased from 40.77 to 68.02, indicating a change in the trend toward higher values in the most frequent data.

On the other hand, the standard deviation increased from 3.32 to 6.94, suggesting that, although productivity improved on average, there is greater variability in the changes observed among the different groups (weeks).

Table 14. Descriptive analysis of pre-test - post-test productivity

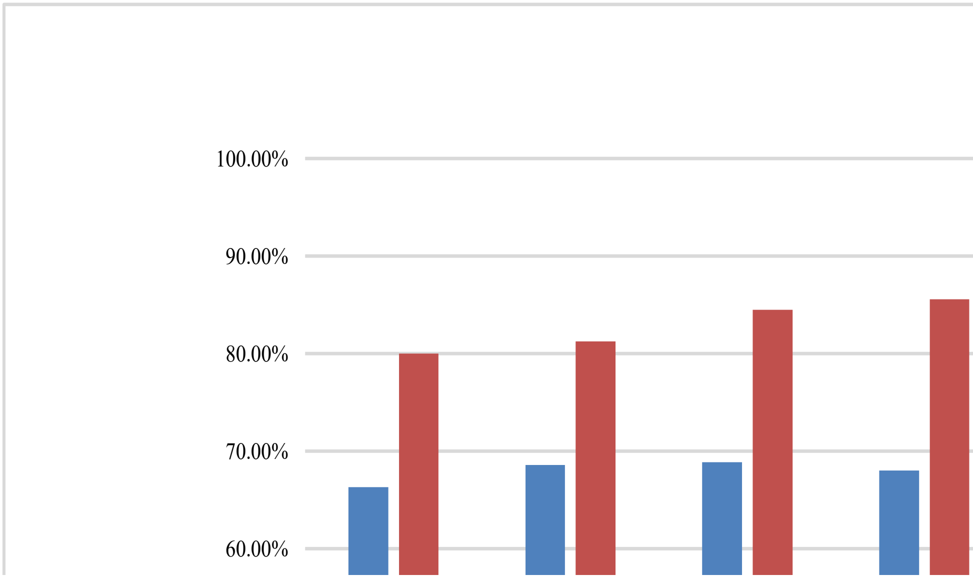
Statistics			
		Productivity Pre-test	**Productivity Post-test**
N	Valid	12	12
	Lost	0	0
μ		46,41	77,49
Md		45,91	79,13
M		40,77	68,02
σ		3,32	6,94

6.4. Efficiency Dimension

Figure 4 shows that, during 2023, the average efficiency was 46.42%. In contrast, in the 2024 post-test evaluation, the average rose to 87.95%, representing a remarkable increase of 41.53% between the two periods. These results show that the implementation has had a positive impact on efficiency.

Table 15 shows a significant increase in efficiency after implementation. The mean increased from 66.85 to 87.92, and the median increased from 67.28 to 88.50, indicating an average improvement in efficiency after the intervention. Likewise, the mode increased from 63.14 to 80.02, indicating a trend toward more efficient levels.

Although the deviation increased from 2.00 to 4.44, its relatively small value indicates that the improvement was maintained steadily over the weeks analyzed. These results are promising and point to a positive effect of the intervention on efficiency.



DETAIL	1	2	3	4	5	6	7	8	9	10	11	12
PRE-TEST	66%	69%	69%	68%	70%	68%	67%	63%	67%	64%	65%	66%
POST-TEST	80%	81%	85%	86%	86%	88%	89%	90%	91%	91%	93%	94%

Fig. 4 Descriptive analysis of the pre-test (12 months of the year 2023) and post-test (12 months of the year 2024) of the efficiency variable)

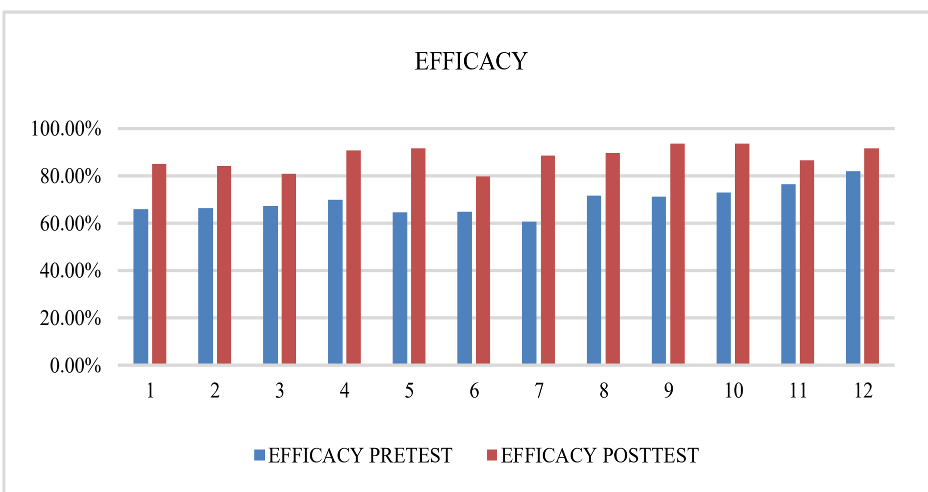
Table 15. Descriptive analysis of the pre-test - post-test efficiency

Statistics			
		Pre-test Efficiency	Post-test Efficiency
N	Valid	12	12
	Lost	0	0
μ		66,85	87,92
Md		67,28	88,50
M		63,14	80,02
σ		2,00	4,44

6.5. Efficacy Dimension

According to Figure 5, the average efficacy in 2023 was 76.02%, while in the 2024 post-test evaluation, this figure rose to 85.65%, showing a remarkable increase of 9.63% between the two periods.

These results clearly show that the methodology had a favorable impact on effectiveness.



DETAIL	1	2	3	4	5	6	7	8	9	10	11	12
PRE-TEST	66%	66%	67%	70%	65%	65%	61%	72%	71%	73%	76%	82%
POST-TEST	85%	84%	81%	91%	92%	80%	89%	90%	94%	94%	87%	92%

Fig. 5 Descriptive analysis of the pre-test (12 months 2023) and post-test (12 months 2024) of the Efficacy variable)

Table 16 shows an increase in the efficacy variable after implementation. The mean increased from 69.51 to 88.01, while the median increased from 68.61 to 89.20, indicating an average improvement in efficacy after the intervention.

The mode increased from 60.73 to 79.78, reflecting a change in trend toward higher values in the most frequent data.

The standard deviation decreased from 5.85 to 4.67, suggesting that the improvement was sustained over the weeks. The results are encouraging and point to the implementation having an effect on efficacy.

Table 16. Descriptive analysis of pre-test - post-test effectiveness

Statistics			
		Pre-test Efficiency	**Post-test Efficiency**
N	Valid	12	12
	Lost	0	0
μ		69,51	88,01
Md		68,61	89,20
M		60,73	79,78
σ		5,85	4,67

6.6. Inferential Analysis

6.6.1. Normality Test

Table 17 shows the results of the normality applied to the productivity, efficiency, and effectiveness variables.

Since the sample size is less than 50, the Shapiro-Wilk test was used to perform the normality analysis.

Table 17. Normality test of the productivity variable and its dimensions, effectiveness, and efficiency

Group		**Shapiro Wilk**		
		Statistician	gl	Sig
Efficiency	Pre Test	0,979	12	0,981
	Post Test	0,955	12	0,708
Efficacy	Pre Test	0,957	12	0,746
	Post Test	0,926	12	0,339
Productivity	Pre Test	0,953	12	0,685
	Post Test	0,874	12	0,074

Student's t-Test for Dependent Samples

General Hypothesis:

H1: Implementation of Operator Focused Management improves productivity in the Steel Industry

H0: The implementation of management with a focus on the operator does not improve productivity in the steel industry.

Significance level: 5%.

Identification of test statistic: t

Decision rule: If the p-value > α, the Ho is not rejected.

If the p-value is ≤ α, the Ho is rejected.

Calculation of the p-value

Tabla 18. Paired samples test productivity

Paired Samples Test Productivity								
	Matched differences							
				95% de Confianza				
	Media	Standard deviation	Measurement of standard error	Inferior	Superior	t	gl	Sig (bilateral)
Prod Pret – Post Test	-31,07	5,97	1,72	-34,87	-27,27	-18	11	< .001

p-value: 0.0000

Decision:

As the p-value in both cases is ≤ 0.05, the Ho is rejected.
Interpretation

A significance value of less than 0.05 was identified, indicating the existence of statistically significant differences between the productivity results obtained in the pre-test and the post-test. Likewise, the positive values indicate that the results of the post-test exceeded those of the pre-test, which supports the acceptance of the stated hypothesis.

H1: The implementation of Operator Focused Management improves productivity in the Steel Mill (see Table 17).

Specific hypotheses:

Specific hypothesis 1:

H1: The implementation of Operator Focused Management improves efficiency in the Steel Industry

H0: The implementation of Operator Focused Management does not improve efficiency in the Steel Mill.

Significance level: 5%.

Identification of test statistic: t

Decision rule.

If the p-value > α, the Ho is not rejected.

If the p-value is ≤ α, the Ho is rejected. Calculation of the p-value

Table 18. Paired samples test efficiency

Paired Samples Test Efficiency								
	Matched differences							
				95% Confidence				
	Media	Standard deviation	Measurement of standard error	Inferior	Superior	t	gl	Sig (bilateral)
Efi Test - Efi Post Test	-21,07	5,73	1,65	-24,71	-17,42	-12,71	11	< .001

p-value: 0.0000

Decision:

Since the p-value in both cases is ≤ 0.05, the Ho is rejected.

Interpretation:

The analysis yielded a significance value of less than 0.05, which evidences the presence of statistically significant differences between the pre-test and post-test results in terms of efficiency.

In addition, the positive ranges showed that the values obtained in the post-test were higher than those of the pre-test, thus supporting the acceptance of the hypothesis (see Table 17).

H1 The implementation of management with a focus on the operator improves efficiency in the steel plant.

Specific Hypothesis 2:

H1: The implementation of Management with a focus on the operator improves the efficiency in the Steel company.

H0: The implementation of management with a focus on the operator does not improve efficiency in the steel company.

Significance level: 5%.

Identification of the test statistic: t

Decision rule: If the p-value > α, the Ho is not rejected.

If the p-value is ≤ α, the Ho is rejected.

Calculation of the p-value

Table 19. Paired samples test efficacy

Paired Samples Test Efficacy						t	gl	Sig (Bilateral)
	Matched differences							
	Media	Standard deviation	Measurement of standard error	95% Confidence				
				Inferior	Superior			
Efficacy Test - Effectiveness Post Test	-18,50	5,81	1,67	-22,19	-14,80	-11,01	11	< .001

p-value: 0.0000

Decision:

Since the p-value in both cases is ≤ 0.05, the Ho is rejected.

Interpretation

It was evidenced that the significance value was less than 0.05, which indicates the existence of statistically significant differences between the pre-test and post-test results in the efficacy variable. Similarly, the positive ranges show that the values obtained in the post-test were higher than those of the pre-test. Consequently, the hypothesis is accepted. H1: The implementation of Operator Focused Management contributes to the improvement of efficiency in the steel industry. The results show that management with a focus on the operator improves productivity in a company. At the same time, it also works on other concepts, such as teamwork, delegation within self-managed cells, stable processes, and a motivating environment, which is demonstrated in better results. Furthermore, it is clear that employee participation has increased, enabling strategic retention. However, while the study shows employee awareness, it also shows that self-managed cells are still a long way off.

7. Discussion

This research conducts a study on the implementation of Operator-Focused Management to improve productivity in the steel industry. The findings obtained in the research are compelling when compared to the results obtained in other studies, which show an improvement in productivity, efficiency, and effectiveness. On the other hand, authors [16, 22] show an increase in productivity in a food industry dedicated to the processing and slaughter of animals for human consumption and steelmaking; however, it is important to highlight that these studies focused mainly on simulations or theoretical analysis. In contrast, the present study is characterized by being an applied research with an explanatory approach, which provides empirical evidence of the results obtained. Likewise, according to the authors [14], in the study "Improving overall equipment effectiveness in Indonesian automotive SMEs: a TPM approach", productivity improved by 15.4%. as well as the authors [28] in their study "Operational excellence of the steel industry using the Lean Six Sigma approach: a case study", its effectiveness in the steel industry improves by 40% after implementation, while in the present study, as can be seen in Figure 3, an increase of 31.07% in productivity was achieved, validating the general hypothesis of the research, which shows that operator-centered management has had a positive impact on productivity.

On the other hand, according to authors [23], in the study "Implementation of Total Productive Maintenance in a Manufacturing SME", productivity in the mechanical and electrical services industries improved by increasing efficiency from 54.23% to 66.90%, resulting in a 12.6% increase in industry. Similarly, according to authors [24], in the study "Improving OEE Performance Using a Lean Six Sigma Approach: A Case Study of Italian Manufacturing", the metalworking industry's efficiency improved by 9.7%.

As in study [25], which shows a 60% improvement in efficiency in the steel industry, in the present research, as can be seen in Figure 4, an increase in efficiency of 41.53% was obtained, which validates the specific hypothesis number 1 of the research, which demonstrates that Operator-Centered Management has had a positive impact on efficiency. Finally, in the authors' research [26], in the study "Measuring the Effectiveness of Overall Performance in Configuration Improvement", in the electronics manufacturing industry, it is observed how, after the implementation of the methodology, the effectiveness improved by 60.45%. Likewise, according to the authors [28], in the study "Increasing Operational Availability in Production in the Agricultural Fertilizer Industry: A TPM Approach with the Internet of Things (IoT)", the efficiency improved by 7.26%, while in the present research, as can be seen in Figure 5, an increase in efficiency of 9.63% was obtained, which validates the specific hypothesis number 2 of the research, which shows that Operator-Centered Management has had a positive impact on efficiency.

Sustainability, understood as the balanced integration of economic, social, and environmental factors, is strengthened when management places the operator at the center, promoting their active participation, shared responsibility, and commitment to continuous improvement. The limitations of this study lie in the fact that the management model is implemented in the context of a specific steel company, which may condition the transferability of the results to other organizations with different structures, levels of automation, organizational cultures, or management approaches. In addition, the operator-centered approach requires a level of organizational maturity that not all steel plants possess, which may hinder its adoption in environments that are less prone to change or resistant to participatory models. On the other hand, the implementation and evaluation time may not be sufficient to observe profound or sustained changes in productivity, which limits the measurement of impact in the short or medium term.

8. Conclusion

With respect to the first objective, which seeks to determine to what extent the change from the current management to Operator Centered Management can improve productivity, it is observed that the average increased from 46.42% in the pre-test to 77.49% in the Post-test, an increase of 31.07%. As for the second objective, which aims to determine to what extent the design and implementation of Operator Centered Management can improve efficiency in the Steel Mill, an increase from 46.42% in the pre-test to 77.49% in the post-test, an increase of 41.53%, is observed. Likewise, the third objective, to determine the extent to which the design and implementation of operator-centered management can improve efficiency in the steel mill, shows an increase from 76.02% in the pre-test to 85.65% in the post-test, representing an increase of 9.63%.

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