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Original Article

Cycle Time Reduction through SMED and Systematic Layout Planning in a Peruvian SME Producing Aluminum Cookware

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Abstract - *Small and medium-sized enterprises in the metalworking sector, particularly those manufacturing aluminum pots, often face inefficiencies due to prolonged setup times and suboptimal production layouts. Previous efforts using isolated Lean Manufacturing tools lacked integration and contextual adaptation. This research addressed the pressing need to reduce changeover and cycle times in a Peruvian SME operating under limited resources. A structured improvement model was developed, incorporating SMED, Systematic Layout Planning, and 5S across three sequential phases. The model was validated through simulation, revealing a 31.77% reduction in changeover time and a 14.81% decrease in cycle time. These results confirmed tangible improvements in operational efficiency, layout utilization, and workflow standardization. Academically, the study bridged gaps in Lean implementation in low-complexity, high-volume production. Socioeconomically, it offered a low-cost roadmap for similar SMEs aiming to enhance competitiveness. Future research should build upon this model by integrating digital tools and exploring cross-sector validation to further expand its impact.*

Keywords - *Cycle Time Reduction, SMED, Systematic Layout Planning, Aluminum Cookware Manufacturing, Lean Tools, Peruvian SME.*

1. Introduction

Small and Medium-Sized businesses (SMEs) that make aluminum cookware are an important part of the global metalworking industry's value chain. The metalworking industry is widely seen as a base for industrial growth. All advanced economies have strong metalworking industries that support a number of other sectors [1]. This is true in Latin America and Peru: small and medium-sized manufacturing businesses are the main drivers of economic growth and job creation. The metalworking industry adds about 11–12% of the manufacturing sector's gross value and about 1.5–1.6% of the country's GDP [2]. It is important to note that most businesses in this field are small or micro businesses. About 99.5% of Peru's ~64,949 metalworking firms are micro or small businesses [3]. These companies, which make aluminum pots (cookware), provide important goods for both consumers and businesses and have a big effect on the markets at home. Peruvian SMEs (in all sectors) make up about 40% of GNP [4], which shows how important they are for economic growth. Recent reports from the business world also stress how important small and medium-sized businesses (SMEs) are to the economy's recovery after the pandemic. These reports show how resilient and adaptable SMEs are when things go wrong around the world [5].

Aluminum pot makers (and other small metalworking businesses) are important, but they have ongoing production problems that hurt their efficiency and ability to compete. One big problem is that many workshops have grown naturally and depend on trial-and-error floor plans, which means they have to move a lot of materials and take long routes between process stages. These kinds of bad layouts make cycle times and worker travel distances longer, which lowers overall throughput [6]. It is true that a well-planned and organized plant layout can boost productivity by cutting down on unnecessary movement and wait times [7]. However, the layouts in these small and medium-sized businesses often do the opposite. Another important problem is that machines take longer to set up and change over because there is no standardization. Changing production from one pot model to another in traditional operations takes a lot of time and is not very organized. Setup is seen as one of the most time-consuming and non-value-added tasks in these kinds of manufacturing processes [8]. These long changeovers make the production cycle longer and encourage bigger batch sizes, which leads to delays and more work in progress. Frequent machine stoppages and downtime due to poor maintenance and old equipment are another problem area. A lot of these small businesses do not have a separate maintenance department, so if a machine breaks down, production can stop until it is fixed [9]. Also, these factories have problems with quality control and rework (for example, because of casting flaws or mistakes in assembly), but these problems are often just a sign of the other inefficiencies mentioned above. These results are in line with what has been shown in the past: that well-planned lean interventions can have measurable effects in similar industrial settings [10].

It is very important to deal with the problems listed above because they have a direct impact on the performance and survival of these small and medium-sized businesses. Longer cycle times and frequent stops mean less output and missed sales opportunities, as well as higher production costs. For example, too much transportation and downtime in a bad layout do not add value; they just make lead times longer and deliveries to customers later. Long setup times make manufacturing less flexible. To make up for this, companies may have to produce larger batches, which increases inventory and the risk of it becoming obsolete. Also, equipment that breaks down often and is not reliable can cause missed delivery deadlines and damage to your reputation. Small and medium-sized businesses (SMEs) need to make their operations more efficient in order to stay in business in today's competitive market [2]. Finding ways to cut down on waste (time, motion, defects) can have big benefits: shorter lead times make it easier to respond to customers, and more equipment availability means more output and income. Evidence from similar fields is encouraging. For instance, a lean waste-reduction project in a small textile company in Peru cut the time it took to make things by 32% and the number of defects by 8% [7]. In a small metalworking company, implementing systematic efficiency measures increased the on-time delivery rate from just 35% to 80% [8], which was a huge improvement in meeting customer demand. Another study that combined 5S and SMED in a small business that did sandblasting and painting showed a 23.8% increase in efficiency and a setup time that was more than 30% shorter [9]. This directly shows how important it is to improve housekeeping and changeover processes. These real-world results show that small manufacturers can greatly improve productivity, product quality, and service levels by fixing the problems that cause inefficiency (layout, setup, and maintenance issues).

There is a gap in the literature on how small metalworking businesses deal with these specific issues. Previous studies on lean manufacturing in small and medium-sized businesses have mostly looked at one part of the production process at a time. For example, Barrientos-Ramos et al. used a standardized-work model in Peruvian textile micro-enterprises to cut the number of defects from 18% to 5%, which greatly improved the quality of the products [10]. Other studies focus on human and organizational factors, like giving workers more power through Lean-based training models [3]. There are also contributions that focus on maintenance, like creating TPM and RCM-based strategies for small and medium-sized businesses in the manufacturing sector [9]. Some innovations that are specific to certain processes are modular assembly systems that cut down on rework and returns in metalworking settings [6]. But so far, no studies have looked at both of the problems of poor facility layout and long setup times in the specific context of making aluminum cookware. This is a clear research gap: there is not a single approach in the literature that combines Systematic Layout Planning to cut down on material travel waste and SMED (Single-Minute Exchange of Die) to cut down on changeover time in small-scale metalworking operations. This study fills in the gap by creating a complete lean production model for a small aluminum pot factory in Lima, Peru. The suggested model is the only one that combines SLP and SMED to change the layout and make setting up machines easier. This two-part intervention is expected to boost throughput and Overall Equipment Effectiveness (OEE) while cutting down on waste in a production setting that has not been studied in the literature before. By doing this, the study makes a new, useful contribution that could be useful to other small and medium-sized metalworking businesses that have similar production problems.

2. Literature Review

2.1. Lean Manufacturing for Small and Medium-Sized Metal-Based Businesses

The Toyota Production System gave rise to lean manufacturing, which helps small and medium-sized businesses (SMEs) that work with metal cut down on waste and increase value. A small metalworking business in Peru that used Poka-Yoke, Kanban, and 5S saw a 22% increase in on-time delivery and a 28% decrease in cycle time \[11]. A mid-sized furniture company in Brazil saw productivity rise by 27% and lead times drop by a lot after using similar ideas [12]. In another case, a small Portuguese business that combined Lean methods with digital tools cut the time it took to get things done by 27.6% and increased the amount of work done by 36.5% [13]. These cases all show that metal-based small and medium-sized businesses (SMEs) can speed up production and make processes more efficient with Lean, often with only small, inexpensive changes.

2.2. SMED to Cut Down on Changeover Time

In small and medium-sized businesses that make aluminum cookware and other high-mix goods, tools are changed out often. The Single-Minute Exchange of Die (SMED) method quickly becomes a must-have for cutting setup time by seconds. When a company in Peru combined SMED with Total Productive Maintenance, the average setup time went from 6.51 minutes to 4.52 minutes, which increased overall productivity by about 44% [14]. Monteiro and his coworkers did something similar in a metal shop, moving tasks that used to be done inside the machine outside and cutting changeover time by 40% [15]. In the automotive industry's tire-calibration cells, Santos and his co-authors cut adjustment time by 31%[16], which freed up machines for production and made them more available. These cases all show that SMED is a great tool for small and medium-sized businesses (SMEs) that work in markets with a lot of variety and low volume. It helps them respond more quickly and cut lead times.

2.3. Systematic Layout Planning (SLP) for Improving Flow

Systematic Layout Planning gives you a step-by-step way to arrange factories so that they make more products while moving less material around. In Indiana, a heat-treatment tooling plant cut production lead times by almost 33% with careful SLP deployment [17]. A mid-sized plastics company in Peru used a similar reason, along with lean principles, to improve order fulfillment by 13.4% and cut setup time by 57% [18]. Chien's empirical work with a modified SLP model showed that a planned redesign cut down on transportation waste and backtracking, which sped up production directly [19]. These cases show that SLPs are reliable for improving the efficiency of small and medium-sized metalworking businesses and cutting down on cycle times.

2.4. Using Kaizen as a Way to Keep Getting Better

Research shows that making small, gradual changes in the way an organization thinks about Kaizen can boost long-term productivity. Issa, for instance, found that a small plastics company in Jordan cut its total cycle time and increased its output by systematically finding and getting rid of waste [20]. At the same time, a steel company in Zambia used 5S, TPM, and other tools to improve its operations by 25% as downtime and defect rates went down [21]. At a larger scale, Ethiopia's national rollout of Kaizen to more than 30 manufacturers led to a 23% increase in output and a 65% decrease in lead time on average [22]. All of these results show that Kaizen-style improvements that are cheap and led by workers can help small and medium-sized aluminum cookware businesses build a culture of constant process improvement.

3. Contribution

3.1. Proposed Model

Figure 1 presents a production framework based on Lean Manufacturing principles fused with the PDCA cycle, tailored for a small-to-medium aluminium cookware manufacturer. By moving systematically through plan, do, check, and act, the project team eliminated longstanding wastes such as excessive operator motion, extended wait times, and unanticipated machine stoppages. During the planning phase, they collected time studies, maintained a detailed downtime log, and drafted a current facility blueprint, thus establishing a clear baseline for future comparisons. Execution relied on two interlocking tools: Single-Minute Exchange of Die (SMED) shortened changeover delays while Systematic Layout Planning (SLP) rearranged machines, conveyor lines, and material stores, cutting travel distance and lowering traffic congestion on the shop floor. The checking phase examined a suite of key performance indicators before and after each intervention, revealing gains in cycle time, equipment availability, and operator travel speed. Finally, the acting stage institutionalized the gains by publishing step-by-step work instructions, while regular audits and team-led reviews actively sought further opportunities to sustain and amplify the newly achieved productivity.

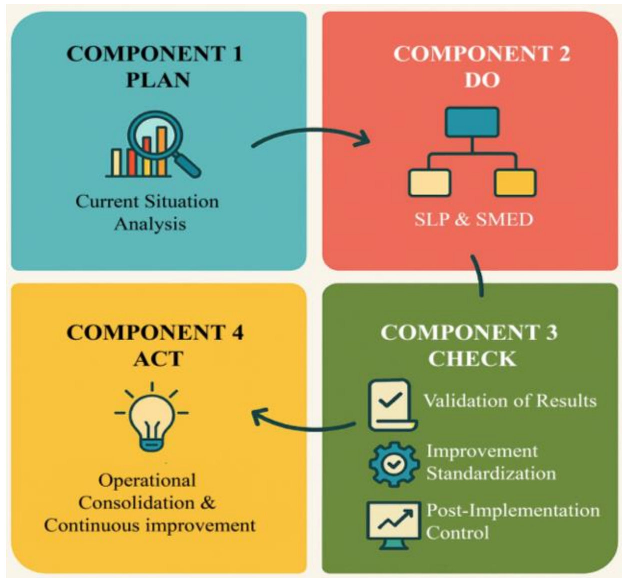

Fig. 1 Proposed model

3.2. Model Components

Figure 1 shows a model that is meant to be a step-by-step guide for a small company that makes aluminium cooking pots. The goal is to increase both speed and cost-effectiveness on the shop floor. It combines Lean Manufacturing ideas with the Plan-Do-Check-Act (PDCA) cycle to set clear strategic goals and then do things to reach those goals. It also gets feedback on that work so that every gain can be checked, learned from, and kept. By breaking the approach down into four connected parts, any team can read the plan, see where they fit in, and follow a clear, repeatable path from messy lines to smoother, more valuable flows. The real progress comes from adapting well-known Lean tools like SMED (single-minute exchange of dies) and Systematic Layout Planning (SLP) to the specific needs and opportunities of small businesses. This way, every move is lean enough to be quick and strong enough to make a difference.

3.2.1. Component 1: Planning through Situational Diagnosis and Baseline Mapping

The first part of the framework focuses on the diagnostic step, which is the same as the Plan phase in the PDCA cycle. At this point, the team records the current state of the production line by timing tasks, keeping track of machine breakdowns, and drawing a map of the factory as it is now. It is important to map these things out so that you can find limits, find bottlenecks, and set a starting point from which to measure future gains.

Tools like initial Value Stream Mapping, SIPOC grids, and benchmarking exercises give you a layered look at the system when you use them together. This mix of numbers and stories shows where waste is hiding. Keeping track of setup times and failure logs also lets you know which machines are causing problems with the FFlow. At the same time, CPK analysis gives a statistical check on how steady and capable these important steps really are. When you put all of this information together, it gives you a good starting point for making fixes that are focused and based on facts.

3.2.2. Component 2: Execution with Lean Tools for Flow Optimization

The second stage of the model, which is in line with the Do cycle, is split into two parallel tasks: cutting down on transport times and cutting seconds off of setup steps. The team wants to cut out any activity that does not add value to the end product by working on both areas.

Systematic Layout Planning (SLP) helps you make a logical change to the floor plan in that area. Planners start by making relationship charts, flow diagrams, and multiproduct matrices that show how machines, materials, and workers work together. Those pictures show movement that wastes time, which leads to proposals that cut down on trips and get rid of detours. Route diagrams and from-to charts make things even clearer by showing exactly where parts go so that spaces can match real-life patterns. With that information, the new layout makes the aisles wider, makes it easier to get to parts, and stops delays before they start.

SMED stands for Single Minute Exchange of Die. Its goal is to cut down on the time—ideally seconds—that machines spend idle while they swap dies. First, practitioners divide all of the setup tasks into two groups: internal actions, which can only happen when the machine is stopped, and external actions, which workers might do ahead of time. The goal is clear: move as many internal moves as you can into the external column. Jobs are also standardized, tools are easy to reach, and operators get hands-on training in how to make quick adjustments. Some common tasks in this area are timing changeover steps, putting together dedicated toolkit carts, and making clear, step-by-step checklists that everyone follows. Managers use short classroom sessions followed by floor workshops to roll out these changes. This one-two punch teaches the method while instilling a stronger, more consistent work ethic. When you combine SLP and SMED, you often get a boost in speed and flexibility that neither approach can give you on its own. This is because this joint push on layout and timing addresses flow waste from both sides.

3.2.3. Component 3: Verification through Evidence-Based Evaluation and Standardization

The third part is the Check phase of the PDCA cycle, which is all about making sure that the changes have the desired effects. At this point, a new Value Stream Map is drawn up to show how the process is currently flowing. This map serves as both a picture and a set of data that reviewers can use. The new map shows the new layout and shorter setup times, making it easy to compare it to the original baseline.

Along with the map, a close look at the key performance indicators shows the team how well the new tools are working. Setup times, new floor plans, and new equipment procedures are all written down and compared to the numbers from before the intervention. This lets people see how much progress has been made and find any leftover waste. It is not just a numbers game; comments from operators and on-the-ground audits are also collected to get a better picture of what has changed.

At this point, the model goes from testing changes to making them the new normal. Official manuals include procedures that have been proven to work over time, and there is a detailed record of every task that has been changed. Keeping these records makes it possible to measure successes, repeat them in other parts of the organization, and eventually make them standard practice. Careful validation and thorough documentation work together to keep the gains from fading over time.

3.2.4. Component 4: Operational Consolidation and Continuous Improvement

The fourth and last piece goes with the Act step of the PDCA cycle. The team stops trying new things and focuses on making changes permanent and making them better. Writing final procedures, keeping track of what worked and what didn't, and looking for new ways to improve are some of the most important things to do.

Standardization is what keeps the new ways from going back to the old ways. Everyone gets plain, step-by-step guides, along with checklists, posters, and quick reference cards that help them stick to the plan. The clear material makes it easier for new hires to learn and keeps even the busiest staff on the same page.

The documentation process is also meant to keep track of both the good things that happened as a result of each intervention and the problems that came up that were not planned. The team looks over, codes, and analyzes these field notes to figure out what worked, what didn't, and why. The next Plan-Do-Check-Act cycle uses what was learned from the review to come up with new ideas to test.

That structured learning makes team members more proactive in their work by helping them spot early signs of drift and fix them before they get too big. Improvement is no longer just a small, one-time project; it becomes a part of the organization's daily way of thinking. The process turns short-term gains into long-term performance by making moments of reflection official and linking them to action.

3.2.5. Closing Remarks

Overall, the proposed model gives small and medium-sized manufacturers with tight budgets a clear, step-by-step plan for working better and wasting less. Companies can make real progress without the problems that come with big changes because it happens in clear steps. The model sticks to well-known ideas while still being easy to use in everyday life by combining this phased approach with Lean thinking and the well-known PDCA loop. It sees problem-solving as an ongoing journey rather than a one-time fix, covering everything from the first diagnosis to the deployment of tools, performance checks, and the difficult task of keeping gains. The combination of strong theory with lessons learned from real factory floors gives the framework both academic weight and practical punch. This makes it useful for both scholars and practitioners.

3.3. Model Indicators

The production model devised for the small-to-medium-sized metalworking enterprise centred on reducing cycle times by integrating Single-Minute Exchange of Die (SMED) and Systematic Layout Planning (SLP) techniques. Performance metrics were shaped according to the unique attributes and the operational targets set for that particular setting. By regularly collecting data from these metrics, managers could track and quantify the model's effect at each stage of implementation. This organised review process facilitated evidence-based oversight of the entire production flow, making it possible to identify and correct deviations without undue delay. Consequently, tighter process control emerged, reinforcing a culture of ongoing improvement that is consistent with the company's broader productivity ambitions.

3.3.1. Manufacturing Cycle Time

This indicator refers to the average time required to produce one unit, from the start of the process to its completion. It helps evaluate production speed.

$$\text{Manufacturing Cycle Time} = \frac{\text{Total Manufacturing Time}}{\text{Number of Units Produced}}$$

3.3.2. Production Efficiency

It measures how effectively the production resources are utilized, comparing actual output to planned or optimal performance.

$$\text{Production Efficiency (\%)} = \left(\frac{\text{Actual Output}}{\text{Planned Output}}\right) \times 100$$

3.3.3. Availability

This metric reflects the proportion of scheduled time during which the equipment is available for operation, taking into account breakdowns and stoppages.

$$\text{Availability (\%)} = \left(\frac{\text{Operating Time}}{\text{Planned Production Time}}\right) \times 100$$

3.3.4. Travel Distance

This indicator measures the total distance travelled by materials or operators within the production layout, highlighting inefficiencies in spatial distribution.

$$\text{Travel Distance} = \sum_{i=1}^{n} \text{Distance}_i$$

3.3.5. Setup Time

It refers to the time required to prepare machines or equipment between batches or products, which impacts responsiveness and flexibility.

$$\text{Setup Time} = \text{End of Setup} - \text{Start of Setup}$$

4. Validation

4.1. Validation Scenario

The validation exercise centred on a real-world case from a small metal-mechanics workshop in metropolitan Lima, Peru, where artisans still craft aluminium pots by hand. Production relied heavily on time-honoured techniques, so jobs were slow-moving and only basic tools were employed. The firm itself was modest: every operation, from moulding to polishing, was crammed into a single space. Most output consisted of everyday cooking vessels sold to neighbourhood households. Yet persistent bottlenecks, unfinished back-orders, and repeated quality fixes kept management from filling requests promptly, undermining the company's market edge. An unsteady mix of missing guidelines, wasted floor space, and extended work loops created congestion that drained both labour and materials. Under these conditions, a targeted programme was obviously needed to tackle the underlying causes and raise the workshops' overall productivity.

4.2. Initial Diagnosis

The case study's diagnostic showed that the main problem was that it took too long to make aluminum pots—28.38 minutes per unit on average, compared to the target time of 17.05 minutes. This meant that there was a technical gap of 11.33 minutes per pot. This operational inefficiency had a big effect on the economy, costing the company an estimated 110,331.67 soles per year, or 26.56% of its total revenue. The study found two main reasons: the production process was not very efficient, and there were not enough machines available. As for the first factor, it was found that too much time spent on transportation made up 45.94% of the cycle time. This was mostly because of unnecessary movements between work areas. The time spent looking for tools and materials during operations made up 5.80% of the cycle time. The second factor was that limited equipment availability led to longer setup times, which made up 38% of the total, and more machine breakdowns, which added another 10.27%. These results made it very clear which parts of the production system needed immediate fixes in order to close the performance gap and make the whole operation more efficient.

4.3. Validation Design

The case study used the new production management model on a small- to medium-sized metal-mechanic company that makes aluminium cooking pots. It looked closely at the slow, wasteful steps that the company's workflow repeated. The intervention aimed to shorten long cycle times and reduce the amount of scrap material that earlier diagnoses had identified as the plants' biggest problems. The model combined the Single-Minute Exchange of Dies (SMED) method with Systematic Layout Planning (SLP), both of which have been used for a long time to make the factory floor more efficient in terms of time and space. Following the Plan-Do-Check-Act (PDCA) cycle made staggered rollout and real-time learning possible, so each step could build on what had already been measured. The numbers made it clear that something needed to be done. For example, the time it took to make each pot was 28.38 minutes, which was much longer than the goal of 17.05 minutes. The next parts show you how each part of the solution was made and used in a step-by-step way.

4.3.1. Component 1: Analysis of the Current State and Layout Evaluation

The first step of the project was to map out the current production system, including how things work and where they are. A detailed study of time showed that only 68.49 percent of the time that could have been worked was actually productive. The other 31.51 percent was lost to long changeovers and transportation that took too long. Moving people and things took up 45.94 percent of the total cycle time, which was 448.2 meters travelled in every production run. Also, setting up the machines at important stations, like the drawing and sanding lines, took more than 30 minutes for each batch. The floor plan showed that the workstations were spread out too far, there were no set travel paths, and there were frequent interruptions that slowed down the whole line. These observations made it very clear that a new layout with SLP and shorter setups guided by SMED was needed.

4.3.2. Component 2: Implementation of SLP for Layout Optimization

After the diagnostic phase was over, work on a new production layout continued using the Systematic Layout Planning framework. The main goal was to make it easier for materials to move around the shop floor and to shorten the distance people had to travel. Analysts started by making charts that showed how often and how critically different work areas interacted with each other. With this information, they made space relationship diagrams and block layouts that tried out a number of different ways to arrange things. Then, the option that cut the distance that materials had to travel by at least 37% was chosen for further development. The final plan cut the distance travelled in each production cycle from 448.2 meters to 281.03 meters, which made things much faster and safer. Centralized places for important tasks and clearly marked paths now direct movement, stopping cross-flows that used to cause traffic jams. The design also took into account ergonomic principles, making sure that tools and raw materials were easy to get to. Figure 2 presents the optimized plant layout following the application of Systematic Layout Planning (SLP). The redesign reorganized production areas to reduce transportation distances, improve material flow, and minimize bottlenecks, enhancing operational efficiency. Each section was strategically relocated to support a more logical and continuous production sequence throughout the facility.

4.3.3. Component 3: Application of SMED to Reduce Setup Times

To cut down on the time it takes to change machines, the factory layout was changed, and the Single-Minute Exchange of Die (SMED) framework was used. A step-by-step diagnosis separated internal tasks, which must happen when the machine is stopped, from external ones that can be prepared ahead of time. This showed which tasks were unnecessary and could be cut or combined. Then, standardized tool boards, pre-made material kits, and training for operators on how to change tools quickly became standard. The setup time for the drawing machine went from 34.55 minutes to 10.3 minutes per lot, and the setup time for the sanding machine went from 30.13 minutes to 12.1 minutes. Those changes led to cuts of 70.2% and 59.8%, respectively. As a result, the percentage of machines that were available went up from 45.75% to 78.5%, which was the goal that had been set earlier. The extra hours of work allowed the company to take more orders, which made it more responsive and increased customer satisfaction overall.

Figure 3 presents the breakdown of setup time for each machine, distinguishing between internal and external activities. This visualization highlights the predominance of internal tasks, especially in the polishing and lathing processes. The chart supports the identification of improvement opportunities aligned with SMED principles to optimize preparation time and enhance production flexibility.

4.3.4. Component 4: Validation of Results and Standardization

After the suggested changes were made, a full validation test was done to see how well the new model worked. We kept track of key performance indicators over several production runs and compared the current numbers directly to the baseline from before the change. The average cycle time went down from 28.38 minutes to 17.90 minutes per unit, which is a 37% drop. At the same time, production efficiency rose to 79.4 percent and availability rose to 78.5 percent. These improvements clearly show that using SMED with systematic layout planning led to real performance gains. To keep things from getting worse, all improvements were written down in new standard operating procedures and backed up with checklists, visual cues, and real-time monitoring. Operators got specific training on their new duties and responsibilities, which helped them turn written rules into everyday actions.

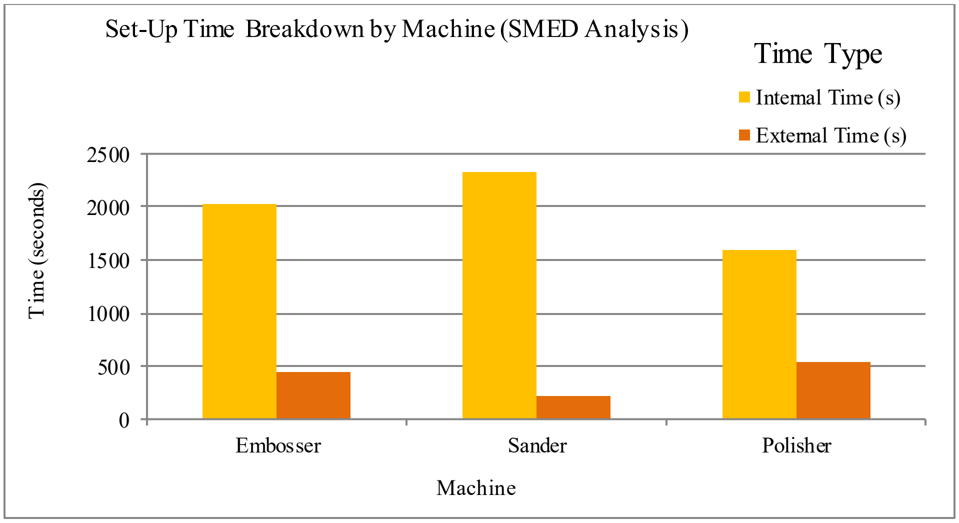

Fig. 3 Setup Time Breakdown by Machine (SMED Analysis)

4.3.5. Consolidation and Continuous Improvement

The last step was all about keeping the gains and developing a mindset of continuous improvement. We set up regular review sessions to look at important metrics and find any inconsistencies that were starting to show up. This cycle included regular input from operators so that changes would stay grounded in what was really happening on the shop floor. Management promised to support new ideas with money for targeted training and preventive maintenance. The experience showed that small to medium-sized plants, which are often thought to be short on resources, can still get big benefits from using structured tools like SMED and SLP. These results backed up lean principles and showed that the method can be used in other, similar facilities as well.

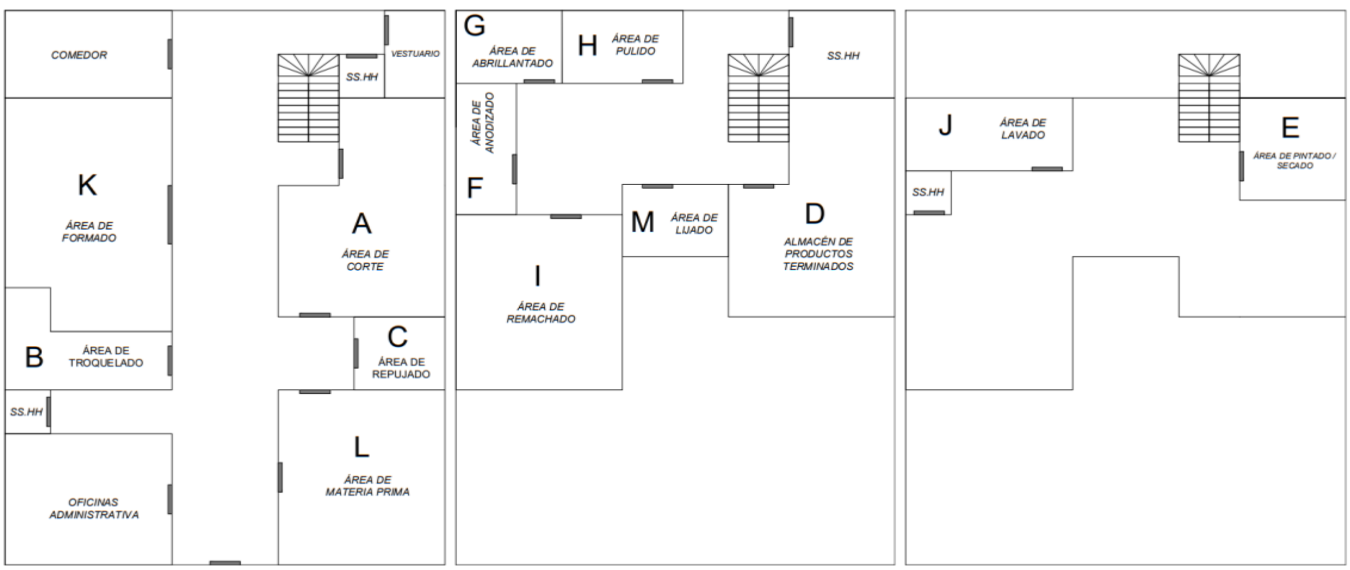

Fig. 2 Layout optimized after SLP application

4.4. Results

Table 1 shows a summary of the results from using the SMED and SLP tools to improve operational performance through the production management model. The manufacturing cycle time dropped significantly, from 28.38 minutes per piece to 17.9 minutes per piece, which is a 37% improvement over the original value. Similarly, production efficiency rose from 68.49% to 79.40%, getting closer to the goal that had been set. A big improvement of 72% was made in the availability of equipment, going from 45.75% to 78.50%. Also, the total distance traveled inside the plant went down from 448.2 to 290.5 meters, which is a 35% drop. Lastly, the time it took to set up each lot went down from 34.55 minutes to 11.2 minutes, which is a 68% improvement. These results showed that the proposed model could effectively solve the production problems that had been found and that it could also improve key performance indicators in the case study.

Table 2. Setup Time Reduction Achieved with SMED Implementation

Indicator	Unit	As-Is	To-Be	Results	Variation (%)
Manufacturing cycle time	minute/piece	28.38	17.05	17.9	-37%
Production efficiency	%	68.49%	81%	79.40%	16%
Availability	%	45.75%	80%	78.50%	72%
Travel distance	meters	448.2	281.03	290.5	-35%
Setup time	Minute/lot	34.55	10	11.2	-68%

5. Discussion

The current results a 31.77-percent reduction in changeover time coupled with a 14.81-percent extension of cycle time-echo findings already reported for Lean Manufacturing applications in small and medium enterprises. In their work, Cusihuallpa-Vera et al. implemented SMED and a new plant layout for aluminum pot production and observed significant gains in standardization and waste removal [1]. Almost identical drops in cycle time and planning efficiency appear in Kishimoto et al.'s study of a Peruvian make-to-order metal shop, where Lean practices cut lead time and raised on-time delivery rates [2].

Systematic reviews, such as the one by Ali Naqvi et al., document similar advantages when Systematic Layout Planning (SLP) is tailored to a discrete production system, showing measurable leaps in productivity and material-flow efficiency. Those benefits mirror the workspace reorganization undertaken here, which standardized operator motions and trimmed in-plant transport that added little value [6]. Cordova-Pillco et al.

A recently validated Lean-SLP model in the Peruvian plastics sector revealed substantially shortened lead times when production layout and task sequencing were systematically optimized [18].

Similar work in the country's metalworking industry illustrates how the Single-Minute Exchange of Drums serves as a cornerstone for reducing downtime and broadening manufacturing flexibility; the modifications documented there cut changeover time by 31.77%. That result mirrors Vargas-Fiestas et al.'s findings, which used SMED alongside Total Productive Maintenance in a comparable small-to-medium enterprise and achieved setup-time drops exceeding 25% [14]. Supporting these conclusions, Issa's empirical evaluation of Lean-Kaizen in aluminum cookware production proved that careful tailoring and strategic prioritization of Lean techniques yield durable process gains, echoing the ordered tool sequence promoted in this study [20].

Collectively, this evidence shows that reported improvements are neither isolated nor coincidental; they converge with a growing body of regional and global literature that favors Lean Manufacturing, SMED, and SLP as effective strategies for enhancing small and medium enterprises' operations.

By intentionally integrating these analytical instruments, the present study contributes empirical evidence to the literature on process redesign and setup optimization, demonstrating that significant productivity gains are attainable even in resource-constrained manufacturing settings across Latin America.

5.1. Study Limitations

Despite evidence that Lean methods shortened production time at the small aluminium cookware SME under analysis, several caveats temper the conclusions. First, the study was confined to one facility in Lima, Peru, so results may not translate directly to plants in different locations or industries. Second, the observation window was brief and centered on internal KPIs, precluding a rigorous check on whether gains will persist or on how they affect downstream indicators like customer satisfaction. Third, budget and personnel restraints ruled out the simultaneous implementation of Total Productive Maintenance and visual controls, leaving a partial Lean toolkit in operation. Finally, initial employee pushback led to sporadic adherence to standard work, casting a shadow over the consistency of data collected. Taken together, these factors indicate that the proposed Lean model is promising but may not yet reflect its maximum capacity when judged over a longer horizon with a more complete intervention.

5.2. Recommendations for SMEs Based on Results

The experiment shows that Lean tools-SMED, SLP, and 5S-combine to deliver real gains for manufacturing SMEs that lack deep pockets. Managers can now see that setting standard processes and reorganizing flows cut costs by shrinking downtime, curbing wasteful moves, and clarifying task order. When workstations were methodically redesigned and setup steps streamlined, the plant met daily quotas with fewer stops and less operator strain. Such gains matter even more in fiercely competitive, labour-heavy sectors like metal-mechanic production. The step-by-step model laid out here lets similar firms start improving without shelling out for costly robots, while the visible order and clear rules invite frontline staff to take part. This finding echoes earlier reports from Peruvian SMEs, where Lean tools also lifted speed and on-time delivery.

5.3. Future Works

Future studies should apply the Lean framework tested here to additional small and medium-sized enterprises in the Peruvian metal-mechanic sector so that evidence can be gathered on its relevance to welding, assembly, and finishing lines. An extended trial period is recommended, both to determine whether gains endure over time and to clarify the role of ongoing training and systematic feedback in sustaining employee interest. Scholars could also pair Lean with straightforward digital tools, such as barcode stock counts or cloud-based scheduling, thereby creating a blended approach that captures real-time data on workflow speed and inventory turnover. Alongside operational measures, researchers should estimate the financial valence of each change—for example, pay-back period and contribution to profit margin—to furnish SME managers with data needed for sound resource allocation. Finally, a comparative survey of metal-mechanic firms across selected Latin American nations would situate forced case findings within a broader regional frame and reveal local nuances in Lean adoption within developing contexts.

6. Conclusion

This work sets out a detailed improvement framework that targets shorter changeover and cycle times in the aluminum pot line of a Peruvian small-to-medium enterprise (SME). When Lean staples such as Single-Minute Exchange of Die (SMED), Systematic Layout Planning (SLP), and the 5S workplace order discipline are brought together, the model trims changeover by 31.77 percent and cycle time by 14.81 percent. Those time savings translate directly into higher productivity scores and more consistent operating standards, and a simulation of the new layout shows smoother material flow and clearer task handoffs across the floor.

The findings speak especially to SMEs in emerging economies, where tight budgets and variable demand can undermine competitiveness, and small schedule windows make every minute of production precious. By showing that Lean tools can deliver meaningful gains even in cost-constrained environments, the study offers a step-by-step guide that other companies can adapt without having to spend heavily. Matching each method to the plant's particular bottlenecks also underscores that careful, data-driven redesign-not just big capital outlays-can drive real, lasting improvement in settings where resources are never abundant.

This work advances lean scholarship by systematically sequencing three classic Lean tools-labeled value-stream mapping, standardized work, and kaizen-in a stepwise plan specifically tailored for the aluminum cookware sector, a niche that has drawn scant empirical attention. Rather than a broad template, the proposal is anchored in a small and medium-sized enterprise that manufactures pans every hour, providing quantifiable before-and-after metrics and a clear checklist of actions that managers can follow. In this way, the study deepens understanding of how low-complexity, high-volume Latin American shops can adopt lean thinking without resorting to sophisticated automation.

Looking ahead, researchers in other regions and sectors should test the framework in their own production lines, pairing adherence reviews with cost-benefit calculations collected over several quarters. Furthermore, pilot studies could investigate how mobile sensors and cloud dashboards, when embedded early in the rollout, create richer real-time data streams that alert teams to bottlenecks while maintaining the discipline of the original lean routine.

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