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Original Article

Addressing Operational Inefficiencies in Custom Jewellery Production through Lean–TPM–SMED Tools: A Peruvian Case Study

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Abstract - *Artisanal gold-jewellery-making in Peru has suffered from frequent machine stoppages and long mould swaps, which delay orders and dent product quality. This research set out to develop and test a Lean-plus-Total-Productive-Maintenance framework designed to lift shopfloor performance while preserving the craft skill embodied in each piece. Over four planned phases, a small export firm was guided through single-minute exchange of dies, scheduled maintenance checks, and real-time metric boards. Data collected after the intervention showed order-fulfilment efficiency climbed by 11 percent, maintenance-compliance rates rise by 24 percent, and mould-change and SMED times dropped by 37 and 38 percent, respectively. These results help fill a scholarly gap by showing that industrial techniques can be adapted for low-volume, highly customized production lines. The framework serves as a step-by-step playbook for jewellery micro and small enterprises, proving that consistent output flow can coexist with artistic craftsmanship in fast-moving export markets.*

Keywords *– Lean Manufacturing, Total Productive Maintenance, SMED, Operational Efficiency, Jewelry Manufacturing SMEs, Artisanal Production Systems.*

1. Introduction

Artisan gold jewellery manufacturing occupies an important niche in the global light industry, with Latin America, particularly Peru, at the forefront. Mejía-Pajuelo et al. [1] document that introducing a Lean management framework in Peruvian micro-and-small enterprises lifted overall performance by roughly 20 percent, and net profits by 15 percent, illustrating both the segment's operational fragility and lucrative upside. Within national accounts, the broader textile-apparel-jewellery cluster now contributes more than 6 percent of Peru's GDP [2], confirming that small, skilled workshops underpin significant employment and export value in a way that closely parallels larger textile factories [3]. Trend watchers also note that equivalent policy frameworks-such as Bangladesh’s gold-sector plan-recognize handcrafted jewellery as an engine of economic growth [4].

Even so, micro and small gold workshops across Latin America routinely contend with systemic inefficiencies, from unscheduled machine outages to time-consuming, non-standard setup routines. Similar investigations among Peruvian textile SMEs have shown that idle equipment and delayed orders stem largely from protracted changeover procedures [2]. Observations in the food-processing sector produce the same conclusion: chronic downtime alongside product defects consistently stifles the growth potential of small enterprises [5]. The garment field yields an almost identical picture, where deviation from standard tasks generates elevated defect rates, disrupted flow, and extended lead times [6],[7]. In jewellery-making, customised fixtures and frequent style changes compound these problems, reducing Overall Equipment Effectiveness (OEE) and obstructing workflow because of repeated machine stops and costly rework cycles.

Responding to these issues is critical. Lean practices and Total Productive Maintenance (TPM) have delivered noticeable gains in small and medium enterprises. For example, streamlining workflows and adjusting the factory layout in a Peruvian garment factory lifted productivity by roughly 10% [8]. A similar effort in a Chinese workshop using TPM raised machine availability and reduced bottlenecks [9]. Combining quick-changeover methods, commonly known as SMED, with TPM creates added momentum; Singh and Ondra [10] observed that the joint implementation improved overall equipment effectiveness more than either approach used alone. Together, these strategies cut setup times and unplanned stoppages, boosting output rates and the dependability of deliveries.

Despite expanding Lean and Total Productive Maintenance (TPM) literature, a specific knowledge void remains: most studies examine mass-production settings or textile mills, not artisanal jewellery work. For instance, Flores-Meza et al. found a 25-percent productivity boost across small Peruvian textile firms, yet did not explore TPM's impact on machine downtime. Likewise, Singh and Ondra surveyed several industries, but their recommendations stop short of curating techniques for goldsmithing. Therefore, our research proposes a blended SMED-plus-TPM blueprint for Peru's gold jewellery micro- and small enterprises. The model addresses high-mix, low-volume production by streamlining tool swaps and tracking bespoke parts. Early tests indicate that combining SMED with TPM yields better overall equipment effectiveness gains than adopting either method alone. The work thus provides practitioners a clear stepwise guide and deepens theory by showing how Lean-TPM tools translate to craft-led manufacturing contexts.

2. Literature Review

2.1. Lean Manufacturing in Gold Jewelry Production

Lean Manufacturing tools-5S, Kaizen, Kanban, and Total Productive Maintenance-have shown promising value in jewelry workshops. Dasgupta and colleagues tried these ideas in a small gold plant, set up visible work boards, and standardized tool sets; non-value time dropped by almost fifty minutes per worker each day, and defects showed up sooner [11]. Espinales-Meza and his team used 5S plus TPM in a related study of Ecuadorian plug-tins, lifted organization scores from forty-four to seventy-four percent, and pushed Overall Equipment Effectiveness from sixty-eight to eighty-six percent [12]. Raymundo and co-authors looked at job swaps in the jewelry line and found that adding SMED-Single-Minute Exchange of Die to lean steps tripled throughput, pushing productivity measures from point thirty-eight to point sixteen [13]. Finally, Altamirano and his group worked with a food-sector SME and showed that SMED paired with FMEA raised OEE by five-point two percent, a sign that lean helps small, high-precision plants like jewelry shops worldwide [14].

2.2. SMES (Small and Medium Enterprise Sustainability) Methodology

SMES offers a structured yet flexible roadmap for small and medium enterprises that seek to increase growth while protecting the environment. Dasgupta and colleagues observed that jewelers operating within this framework gained resilience during market swings: by standardizing tasks, units became less reliant on a single skilled artisan, a finding particularly relevant for the gold sector [11]. Echoing this, Espinales-Meza and co-authors showed that lean tools combined with Total Productive Maintenance in one small workshop sped up output and lifted staff morale, tying operational gains to social sustainability outcomes [12]. Raymundo added that when lean practices were calibrated to the tighter budgets and teams of many SMEs, overall productivity climbed without compromising long-term environmental targets [13]. Supporting this trend, Kaspin demonstrated that applying Six Sigma's DMAIC loop in a Malaysian jewelry firm refined scrap collection and tracking, cutting waste and tightening resource use in line with global sustainability norms [15].

2.3. Autonomous Maintenance in Artisan-Like Manufacturing

Autonomous Maintenance strengthens the bond between production staff and equipment upkeep, encouraging workers to take ownership and tackle problems before they escalate. Ferreira and Leite showed that teaching operators to perform daily cleaning, lubrication, and inspections at a Brazilian electronics plant boosted machine reliability and cut surprise stoppages [16]. Sharma and Sanjit studied an FMCG packing line and found that moving through a phased AM routine-basic cleaning, skill-building, and condition checks-improved overall equipment effectiveness, reduced defects, and raised operator morale [17]. Espinales-Meza and colleagues recorded a noticeable OEE gain after early TPM Stage 1 actions, underscoring Autonomous Maintenance's usefulness even in small-batch settings [12]. Altamirano's team reported that launching AM before rolling out full TPM led to quicker gains in machine uptime and steadier product quality [14].

2.4. Structured Planned Maintenance for Jewelry Workshops

Planned Maintenance (PM) sits at the heart of any reliability-centred production approach, aiming to catch potential equipment faults before they catastrophically develop. Altamirano and co-workers proposed, and tested in a small food-processing plant, a PM protocol that blends Single-Minute Exchange of Die (SMED) timing lessons with Failure Mode and Effects Analysis (FMEA) checks; their intervention produced measurable gains in Overall Equipment Effectiveness (OEE) and more consistent output [4]. Ferreira and Leite then installed a two-layer system, in which trained machine operators carry out daily inspections and basic fixes while specialist technicians address more complex failures, a redistribution that has simplified work orders and cut average downtime [16]. Sharma and Sanjit report similar gains when disciplined PM cycles are coupled with Autonomous Maintenance (AM); their data show a marked drop in surprise stoppages and a measurable extension of critical asset life [17]. A parallel study by Espinales-Meza and colleagues highlights the additive value of workshop-cleaning routines drawn from 5S and of Total Productive Maintenance (TPM) key-performance indicators, which together reduced cycle time and boosted overall productivity in a labor-intensive micro-enterprise [12].

Within jewelry production, where dimensional accuracy, material preservation, and on-time delivery are paramount, a structured PM regimen is indispensable for safeguarding process reliability and achieving consistently high output quality.

3. Contribution

3.1. Proposed Model

Figure 1 illustrates a production model designed expressly to tackle the low efficiency recorded along the gold-jewellery manufacturing line, drawing on Lean Manufacturing fundamentals and the Total Productive Maintenance (TPM) framework. The approach unfolds in four interrelated stages. First, in the preparation phase, non-standard procedures were mapped, and staff awareness was raised; next, the introduction phase established role clarity and managed the necessary organizational change. The implementation stage is split into two complementary tracks: one introduced planned maintenance, relying on machine condition checks, monitoring systems, and early-warning diagnostics, while the other applied the SMED system, which pinpointed, streamlined, and documented both internal and external setup tasks in order to shorten changeover times. Finally, the ongoing indicator-monitoring phase energized continuous improvement by closing the loop with corrective feedback and by nurturing a stronger asset-care culture. Within this jewelry producer, the model aimed squarely at lifting production-flow efficiency without sacrificing the artisanal quality of each piece or jeopardizing promised delivery schedules.

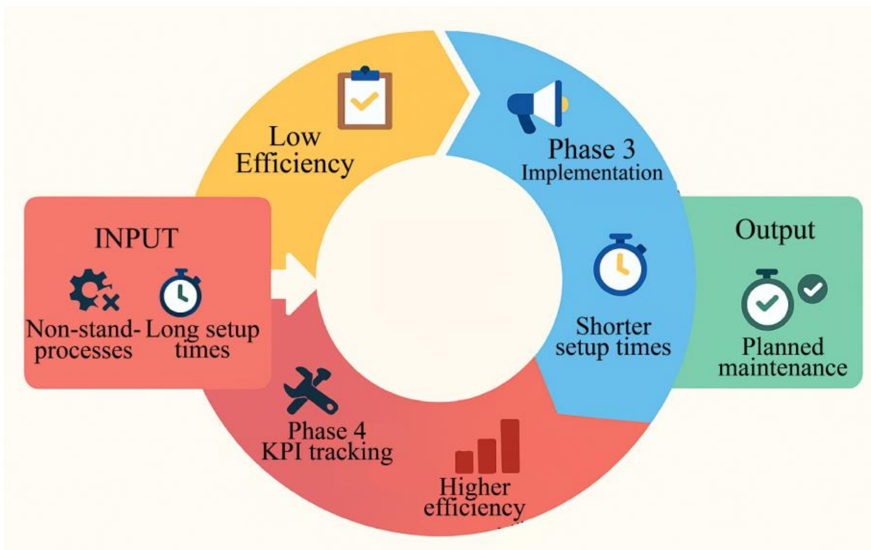

Fig. 1 Proposed model

3.2. Model Components

The conceptual framework shown in Figure 1 draws heavily from Lean Manufacturing tenets and the proactive focus of Total Productive Maintenance (TPM) while weaving in Single-Minute Exchange of Die (SMED) techniques to trim away moments that do not add value. Its central objective is to remedy deep-rooted issues in the gold-jewellery line that slow flow, particularly tangled work habits, long setup periods, and a patchy approach to upkeep. Organized into clear phases, the model seeks to lift machine uptime, steady cycle behaviour, and speed changeovers-three traits that matter most in a craft where each piece is both unique and exacting. By offering this step-by-step playbook, the work enriches continuous-improvement literature and shows how small, flexible shops can pair nimbleness with dependable output to stay sharp in a competitive market.

3.2.1. Phase 1: Strategic Preparation for Operational Transformation

The opening phase of the model lays the groundwork needed before any new technology or procedure can be introduced. It emphasises that meaningful improvement can only occur once everyone agrees on what the challenges are and is willing to work together toward a solution. Consequently, the change effort begins with an in-depth assessment of the existing production line, spotlighting the key sources of wasted time and effort. The diagnostic probe reveals three related problems: work procedures that differ from one operator to the next, lengthy and erratic setup times, and a maintenance regime that either runs in isolation or is skipped entirely. These issues create bottlenecks that push delivery dates out, increase daily variability, and reduce the time machines spend on the production floor.

To complement the technical fixes, the work stream rolls out a sensitisation campaign aimed at shopfloor staff, engineers, and supervisors, so everyone shares the same commitment to the upcoming changes. Senior managers recognise that lasting gains rest not only on new tools but also on a genuine shift in mindset, especially in places where tacit, unspoken knowledge has been king for years. Written charters spelling out each person's duties are circulated, cutting away the grey areas that normally spark frustration and slow progress later. When roles are clear, coordination tightens, and the usual resistance to change starts to thin. This preparatory phase thus delivers both organisational clarity and the technical insight that later steps will build on.

3.2.2. Phase 2: Establishing the Continuous Improvement Framework

With preparatory groundwork rattling behind it, the introduction phase shifts toward weaving a disciplined culture of continuous improvement into the workshop. Each jeweller is brought face-to-face with Lean Manufacturing and Total Productive Maintenance through brief, tailored sessions that connect the ideas-cut waste, honour value-adding time, share equipment care-directly to the flow of turning raw gold into finished pieces. Theory is stitched to practice in hands-on gemba walks and guided simulation drills where operators hunt for and sketch the wastes they see in their own motions.

At the same time, a light-touch governance skeleton begins to take shape. Cross-functional micro-teams pulled from design, polishing, casting, and finishing adopt portable tools-SMED, 5S, and visual boards-as process owners for their slice of the line. Pushing authority to the front slows bottlenecks since small decisions can be made on the spot, spotting trouble earlier and nurturing a low-risk habit of fixing it.

Backing this autonomy, clear technical bullets pinned with data indicate which machines, stations, and shifts deserve the teams' scarce hours first. The introduction phase makes improvement feel normal, stitching it into the company's wider growth rhythm.

3.2.3. Phase 3: Operational implementation carried out through two core actions

The third phase marks the transition from planning to doing in the proposed model, when targeted technical activities are put into practice to lift overall efficiency. This stage is organized around two overlapping initiatives: maintenance planning rooted in the Total Productive Maintenance (TPM) philosophy and setup time trimming guided by the Single-Minute Exchange of Die (SMED) method.

Component 1: Planned maintenance management in line with TPM

The opening step is to create a disciplined maintenance system that secures the availability of the production floor s most critical machinery. To launch the initiative, each unit undergoes a thorough health assessment that tracks failure patterns, gauges component wear, and ranks the machines according to their impact on overall output. The resulting diagnosis informs a control calendar that specifies both preventive and predictive tasks, scheduling them well ahead of time.

A key benefit of this regime is moving away from an emergency repair culture toward a maintenance plan driven by hard data and the rhythm of production. A digital board logs completed work, highlights actions based on equipment priority, and feeds measurable targets back to the crew. Operators receive training to perform routine checks and simple fixes, embodying the Total Productive Maintenance principle of autonomous care and helping to close the maintenance loop more quickly.

In jewellery production, even tiny deviations in tool alignment can undermine value, so machines need to perform consistently. For this reason, equipment reliability sits at the heart of the improvement plan: by cutting unplanned outages, it locks in tighter process control and feeds into the larger goal of higher plant efficiency.

Component 2: Changeover time optimization through SMED

The second focus spotlights a thorny bottleneck setup delay that appears whenever the line shifts from one design to another. Given the sector's frequent style swaps, the speed with which each machine can be reconfigured soon shapes overall throughput and, by extension, profitability.

SMED methodology for Single-Minute Exchange of Die is therefore introduced to slash these changeover windows in a disciplined way. First, teams map every step of the sequence, pointing out where the machine must run and where people can prep in advance. Once this inside-outside split is clear, tasks are reordered, waste is deleted, and calibration procedures take on a leaner, faster form.

This activity also includes training personnel who will carry out the changeovers, building the precise skills needed at each step. Standard work for the setup process is then documented and made available, so new operators can follow the same routine and climb the learning curve faster. The combined effect is an operation that moves more quickly, behaves more predictably, and makes fewer mistakes, all of which lift the effective availability of the production system.

These two sets of actions reinforce each other to produce a production environment that is both dependable and adaptable. While planned maintenance keeps equipment in peak condition, the SMED techniques cut away the time that adds no value during tool changes. Together, they boost line efficiency and free the system to respond swiftly when market demand shifts.

3.2.4. Phase 4: Monitoring outcomes and sustaining improvements

The final stage centres on tracking outcomes over the long haul and ensuring that early wins endure well after the heavy lifting is finished. To this end, straightforward monitoring gadgets are set up so managers can gauge the contribution of each tweak in real time. The guide avoids prescribing every conceivable indicator, yet it emphasises that regular examination is the surest way to stay improvement-minded and catch drift before it grows costly.

Oversight is sustained through routine review huddles where downtime, stability gains and schedule compliance are examined in figures and stories. These sessions become a communal notebook for codifying successful tricks, spotting spots where standard practice can spread deeper, and sharpening responsive actions when performance wobbles.

That team-first spirit of equipment stewardship and broader efficiency is deliberately cultivated. Praise programmes, bite-sized refresher clinics and appropriately weighted scorecards keep care of assets at the forefront of every operator and supervisor. By framing sustainment as a living task rather than a finish line, the monitoring phase guards earlier gains and steers them toward even loftier goals.

Figure 1 lays out a custom improvement playbook for the gold inner jewellery workshop. Split into carefully timed phases, the plan pairs Lean tools with disciplined upkeep so confidence can build before change is scaled.

When used together, Total Productive Maintenance and Single-Minute Exchange of Die target equipment reliability and fast changeover- a pairing essential whenever manufacturing artistry must match fluctuating order patterns.

3.3. Model Indicators

Operational efficiency in the gold jewellery manufacturing facility was assessed using performance metrics specifically designed around Lean principles and Total Productive Maintenance. These custom measures were modified to fit the workshop's unique workflows, enabling a step-by-step review of progress as changes were rolled out. By working within this framework, managers could monitor critical variables reliably, gaining a sharper picture of how and why performance was shifting. The ongoing assessment habit embedded in the model guaranteed that every strategic move was guided by hard data rather than assumptions, keeping improvement efforts closely aligned with the jewellery sector's distinct operating conditions.

3.3.1. Fulfilment Efficiency

Captures the percentage of customer orders fulfilled as promised; it rises when lost orders decline, signalling smoother flow, better inventory coordination, and timely dispatch.

$$\text{Fulfillment Efficiency} = \left(1 - \frac{\text{Lost Orders}}{\text{Total Orders}}\right) \times 100$$

3.3.2. Maintenance Noncompliance

Measures the proportion of scheduled maintenance tasks that were missed or delayed, highlighting execution gaps that can elevate breakdown risk and undermine equipment reliability.

$$\text{Maintenance Noncompliance} = \frac{\text{Missed Maintenance Tasks}}{\text{Total Scheduled Maintenance Tasks}} \times 100$$

3.3.3. High Changeover Times

Represents the average hours required to shift the line between product types requiring substantial adjustments; shorter intervals free capacity and smooth mixed-model production.

$$T_{\text{CO}} = t_{\text{end}} - t_{\text{start}}$$

3.3.4. SMED Time

Quantifies the elapsed hours to complete a single-minute exchange of dies event; reductions mirror successful separation of internal activities and faster return to value-adding flow.

$$T_{\text{SMED}} = t_{\text{end}} - t_{\text{start}}$$

4. Validation

4.1. Validation Scenario

The validation study was conducted in a medium-sized jewellery manufacturer and exporter based in Lima, Peru. After more than thirty years in business, the firm employs 350 people and occupies a 2,600-square-meter workshop, making it the largest Peruvian exporter in its industry. Roughly 98 percent of production is sold abroad, with the United States and a handful of other markets absorbing most shipments. The company organizes its workflow into several units. Yet, the mechanized chain line is regarded as critical because it receives the highest volume of orders and generates the bulk of revenue. Despite this strategic importance, archived data show persistent drops in operational efficiency, reflected in cancelled jobs and missed delivery dates. Such evidence led managers to commission the present inquiry to pinpoint root causes and map feasible paths for performance recovery.

4.2. Initial Diagnosis

The case study's diagnosis showed that the gold chain production line's low efficiency was mostly due to interruptions in operations and poor process management. The study found that 49% of the total losses were due to machinery downtime. Of these, 30% were due to not having a structured preventive maintenance plan, and 19% were due to longer changeover times. Also, planned stoppages accounted for 43% of the inefficiencies, which were directly related to longer setup times, which also accounted for 43%. This shows that setup procedures need to be changed. Production defects added another 8% to the overall problem, though not as much as other things. This was linked to the lack of standardized processes, which accounted for 5%, and poor-quality control, which accounted for the last 3%. All of these results made it possible to pinpoint the exact areas that needed intervention to bring productivity back up. This helped guide efforts to improve by lowering unplanned downtime, making format changes more efficient, and improving quality assurance practices.

4.3. Validation Design

Over a four-month pilot study at a gold jewellery workshop, researchers validated a production management model built on Lean practices and Total Productive Maintenance (TPM). The trial aimed to boost operational efficiency by cutting setup times, standardizing core tasks, and strengthening preventive maintenance schedules. A step-by-step rollout featured specific tools designed to tackle daily bottlenecks, especially those linked to machine availability and changeover activities. Each adjustment was tracked with data-driven metrics, providing a transparent view of gains achieved and the likelihood that these improvements would endure in the shop floor culture.

The model shown in Figure 1 draws on Lean Manufacturing concepts, reinforces them with Total Productive Maintenance (TPM), and folds in Single Minute Exchange of Die (SMED) techniques to cut out wasted time. It was developed specifically to fix the deep-rooted problems holding back efficiency in the gold jewellery production line, such as uneven work methods, long setup intervals, and the lack of a planned maintenance system. Organized in clear, step-by-step stages, the approach seeks to lift machine uptime, stabilize production variations, and speed up change-overs- all critical in a market that demands both custom styles and precise finishes. By framing continuous improvement in this modular way, the study gives small-scale makers a practical, field-tested blueprint that balances the need for agile, reliable operations to stay competitive.

4.3.1. Phase 1: Strategic preparation for operational transformation.

Phase one sets the groundwork for any later changes to the way operations are run. Before introducing new tools or systems, the team must agree on what the problem is and want to fix it together. To spark that agreement, leaders commission an in-depth review of the production line, hunting for the main barriers that slow work and push costs up. Analysts zero in on three recurring frictions: procedures that teams follow in differing ways, setup times that run longer than necessary, and an unplanned approach to machine upkeep. When these frictions pile up, they choke workflows, stretch lead times, and leave equipment idle more often than expected.

The phase also pairs the technical review with a sensitization campaign aimed at the shopfloor and maintenance staff. Managers know that tools alone will not change outcomes; attitudes and daily habits must shift too, especially in cultures where hand skills carry great weight. At the same time, clear role maps spell out who will do what during the coming work, easing coordination and taming the doubt that often greets new initiatives. In short, this early-stage supplies both the insight and the buy-in that a later, step-by-step rollout can leverage to lift performance reliably.

4.3.2. Phase 2: Laying the Groundwork for Continuous Improvement

With planning now complete, the project shifts toward building a steady culture of change grounded in method and evidence. During this phase, the bedrock principles of Lean Manufacturing and Total Productive Maintenance are explained in concrete terms, illustrating how each directly affects the day-to-day work of gold jewellery production. Hands-on workshops and guided group exercises demonstrate concepts such as trimming waste, expanding value-added time, and passing basic equipment care responsibility from specialists to operators themselves. A light governance structure then oversees these activities by linking every improvement project across the shop floor. At its core, cross-functional task cells apply the new tools in their areas, pushing decision-making closer to the work, catching problems early, and nurturing everyday leaders. In tandem, clear technical guidelines emerge that rank machines, processes, and shifts according to the urgency of intervention. Together, these elements provide a disciplined road map that aligns day-to-day improvements with the company's long-term strategic objectives.

4.3.3. Phase 3: Operational Implementation through Two Key Components

During Phase 3, the model moves from planning to real-world execution, translating theoretical efficiency gains into daily practice on the production floor. To keep activities organised and mutually reinforcing, the phase is divided into two interlinked streams: maintenance planning grounded in Total Productive Maintenance (TPM) and setup-time reduction driven by the Single-Minute Exchange of Die (SMED) method.

Component 1: Planned Maintenance Management Based on TPM

The first stream aims to create a structured maintenance calendar that maximises the uptime of high-impact machines. Work begins with a detailed condition audit, in which wear profiles, historical failures, and each unit's contribution to throughput are mapped. This data feeds a governance tool that schedules both preventive and predictive tasks according to criticality and parts availability.

By treating maintenance as a forward-looking programme instead of a stopgap, the plant shifts culture and capability at once. A digital log tracks completed work, alerts teams before due dates, and computes availability metrics that close the performance loop. Operators also join in basic inspections and cleaning, reinforcing TPM's philosophy of shared ownership.

In jewellery production, where the smallest inaccuracy may ruin a piece, every tool must work exactly as expected. For this reason, the reliability of every machine sits at the centre of the improvement plan, since fewer unexpected breakdowns give the shop floor steadier output and higher overall efficiency.

Figure 2 presents the production area's Cleaning Standard Operating Procedure (SOP). It outlines sequential tasks, responsible personnel, frequency, duration, required protective equipment, cleaning materials, and safety warnings, ensuring hygiene, safety, and standardization during the machine cleaning process within the work cycle.

EMPRESA: XYZ	MÉTODO ESTÁNDAR DE LIMPIEZA (MEP)					VERSIÓN	CÓDIGO HEP
LINEA/AREA: Proceso de Producción	PROCESO: Limpieza de las máquinas	TIEMPO DE CICLO:		FECHA:	REALIZADO:		HOJA 1
Área de limpieza	Actividades a ejecutar	Variable	Duración	Herramientas	EPPS	Riesgos	Adicionales
sistema de lubricación	1.1. Se debe abrir la cubierta que se encuentra en la parte superior	Quitar la suciedad de la máquina	5 minutos				
	1.2. Se debe limpiar con cuidado el sistema de lubricación con una esponja blanca escurrida						
	1.3. Se procede a cerrar las cubiertas						
motor	2.1. Se debe colocar brocex a la escobilla utilizado	Quitar la suciedad de la máquina	3 minutos				
	2.2.Se debe pasar la escobilla seleccionada por el área del motor						
	2.3. Se debe proceder a pasar una manguera de un extremo a otro ,teniendo en cuenta el coller en seco						
	2.4. Se debe hechar talco al extremo del motor						
	2.5. Por el otro extremo de la manguera , se debe pasar la manguera hasta el centro del coller						
	2.5. Se debe aplicar el talco a un waper						
	2.6. Se debe pasar una waper con talco por los platos de pre						

Fig. 2 Cleaning standard operating procedure

Figure 3 shows the Lubrication Plan, which schedules maintenance activities for various machines across a six-month period. It details the equipment, responsible personnel, specific lubrication points, and frequency of tasks, ensuring proper functioning and minimizing mechanical wear through systematic preventive maintenance.

EMPRESA XYZ			PROGRAMA DE LUBRICACIÓN DE LAS MÁQUINAS -MENSUAL																					
Máquina	Área a lubricar	Parte	AÑO																					
			ENERO					FEBRERO				MARZO				ABRIL					MAYO			
			S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15	S16	S17	S18	S19	S20	S21	S22
Máquina de corte	Área de engrase	Motor		P					P				P					P					P	
	Área a lubricar	sistema de transmisión		P					P				P					P					P	
	Área a lubricar	Sistema de control		P					P				P					P					P	
Máquina de soldadura	Área de engrase	Ssitema de lubricación			P					P				P					P					P
	Área de engrase	Estructura de soporte			P					P				P					P					P
	Área a lubricar	sistema de seguridad			P					P				P					P					P
	Área a lubricar	sensores			P					P				P					P					P
Máquina de tratamiento termico	Área de engrase	Controlador		P					P				P					P					P	
	Área de engrase	sistema de sujección		P					P				P					P					P	
	Área a lubricar	Fuente de energia		P					P				P					P					P	
Máquina de pulido	Área de engrase	Camara de tratamiento		P					P				P					P					P	
	Área de engrase	Sensores			P					P				P					P					P
	Área a lubricar	Cargador de piezas			P					P				P					P					P

Fig. 3 Lubrication plan

Figure 4 presents the Lubrication Standard Operating Procedure, detailing step-by-step tasks for cleaning and lubricating machine components. It specifies the responsible personnel, task sequence, duration, protective equipment, materials used, and safety warnings. This standard ensures proper machine performance, reduces wear, and promotes workplace safety through preventive maintenance practices.

EMPRESA: Empresa XYZ	MÉTODO ESTÁNDAR DE LUBRICACIÓN (MEP)					VERSIÓN	CÓDIGO HEP
LINEA/AREA: Proceso productivo	PROCESO: Lubricación de las máquinas	TIEMPO DE CICLO:		FECHA:	REALIZADO:		HOJA 1
Área de limpieza	Actividades a ejecutar	Variable	Duración	Herramientas	EPPS	Riesgos	Adicionales
Engrasamiento	1.1. Se debe aplicar en el área de motor	Reducir los residuos	10 minutos				
	1.2. Es importante quitar el excedentes de grasa						
Lubricación	2.1. Se debe lubricar los subsistemas	Reducir los residuos	10 minutos				
	2.2.Se debe lubricar lo subsistemas						
	2.3. Se precede a realizar la lubricación de los subsistemas						
	2.4. Se debe limpiar los excedentes extremos de los subsistemas						
	2.5. Se debe lubricar los subsitemas						
	2.7. Se debe colocar lubricantes a los subsistemas						
	2.8. Se debe limpiar los excendentes						

Fig. 4 Lubrication standard operating procedure

Figure 5 presents a Planned Maintenance Plan outlining preventive tasks for specific machines, including the type of maintenance, frequency, responsible personnel, and execution dates. This schedule helps ensure equipment operability, prevents failures, and supports the continuity and reliability of the production process.

Mantenimiento Planificado							
Hojas de rutas							
Responsable		Mantenimiento	Area		Proceso productivo fabricación de cadenas de oro		
Fecha			Equipo		Máquinas		
Máquina	Descripción	Área de trabajo	Detalle	Horas	Unidad	N° trabajador	Fecuencia
Máquina de corte	Manual	Producción	Se realizó la limpieza general de la máquina de corte.	2	Hr	1	Diario
Máquina de corte	Manual	Producción	Se inspeccionó la existencia de fugas de aceite en la máquina.	3	hr	1	Semanal
Máquina de corte	Manual	Producción	Se revisaron las fugas en la tubería de alta presión.	2	Hr	2	Mensual
Máquina de corte	Manual	Producción	Se cambiaron los bujes anudadores frontal y posterior de la máquina	1	Hr	1	semestral
Máquina de corte	Manual	Producción	Se reemplazaron los ganchos de agarre del mecanismo de corte.	2	Hr	1	mensual
Máquina de corte	Manual	Producción	Se realizó la inspección del sistema eléctrico de la máquina.	3	Hr	1	Mensual
Máquina de corte	Manual	Producción	Se verificaron las condiciones del filo de las cuchillas de corte.	2	Hr	1	bimestral
Máquina de corte	Manual	Producción	Se comprobaron los niveles de lubricación en los componentes móv	2	Hr	2	mensual
Maquina de prensa	Manual	Producción	Se realizo la limpieza general de la maquinaria	1	Hr	1	diario
Maquina de prensa	Manual	Producción	Se revisaron las fugas en las mangueras de alta presión.	2	Hr	1	Mensual
Maquina de prensa	Manual	Producción	Se verificaron y ajustaron los ganchos de sujeción de las piezas	3	Hr	1	Mensual
Maquina de prensa	Manual	Producción	Se realizó la inspección del sistema eléctrico de la máquina.	2	Hr	2	Mensual
Maquina de prensa	Manual	Producción	Se revisaron las condiciones de los moldes y matrices utilizados.	1	Hr	1	semestral
Maquina de prensa	Manual	Producción	Se comprobaron los niveles de lubricación en los componentes móv	2	Hr	1	Mensual

Fig. 5 Planned maintenance plan

Component 2: Changeover Time Optimization through SMED

Next on the agenda is perhaps the most frustrating delay on the line: the long minutes or hours spent switching from one product reference to another. Because jewellery orders usually vary in design, the speed at which a team can ready a machine often decides how many pieces can be delivered on time.

To shorten these pauses, the factory adopts SMED, a step-by-step method that separates tasks done while a machine runs from those that demand a stop. First, each changeover move is documented, the running and idle steps are listed, and then redundant motions are cut away or redesigned so that setups take only the time absolutely needed.

In addition, this element incorporates structured training for personnel conducting changeovers, thereby cultivating the precise competencies needed at each phase of the operation.

Standardization of the setup procedures is strongly encouraged, which not only permits uniform replication but also accelerates the learning curve of novice operators. The cumulative effect is an agile, predictable, and error-tolerant process that markedly boosts the effective availability of the entire production system.

The two components work in tandem to forge a more dependable and adaptable manufacturing landscape. Where planned maintenance guarantees that equipment performs at peak levels, SMED execution trims away unnecessary time at changeovers. This dual approach lifts line efficiency and equips the factory to respond swiftly to shifting market signals.

Figure 6 illustrates the reduction in changeover time for the chain manufacturing machine. The process duration decreased from 92 to 77 minutes after applying SMED. The chart highlights task sequencing improvements and distinguishes total time with dashed lines, emphasizing gains in efficiency and operational agility.

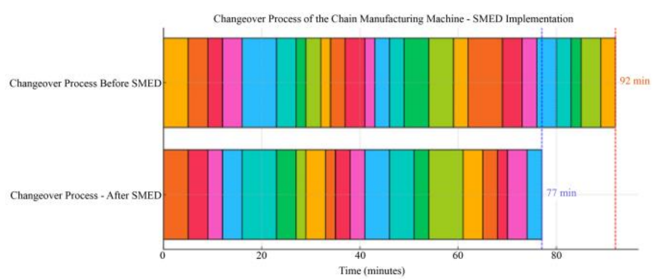

Fig. 6 Comparison of Changeover Process Before and After SMED Implementation

Phase 4: Monitoring Outcomes and Sustaining Improvements.

The concluding phase of the model proceeds in an orderly manner, first tracking the improvements achieved, then ensuring they settle in as daily practice. At this juncture, dedicated monitoring tools-whether dashboards, scorecards or real-time sensors-are rolled out to measure the precise impact of earlier interventions on key performance indicators. Although no specific numbers are cited in the discussion, the text acknowledges that steady oversight is crucial to keep momentum alive and catch any slip before it widens. Regular review meetings form the backbone of this oversight, giving teams a scheduled space to parse the data through the lenses of reduced downtime, greater system stability and on-time delivery. In these forums, members share winning tactics, identify procedures ready to be codified and adjust action plans in light of the freshest evidence. The dialogue is disciplined yet informal, fostering a joint learning atmosphere rather than a blame-oriented audit. Alongside the data-driven checks, the firm actively steers a culture that prizes sound asset care and broad operational efficiency. The cultural push comes through formal awards, job-filling skill clinics, and the integration of clear technical metrics into annual performance reviews. By closing the improvement loop with a forward-looking, future-oriented bias, the monitoring phase protects gains from the gradual slippage known as regression and invites them to blossom into still higher standards.

Figure 1 presents the model as a unified, context-rich roadmap customised for a small gold-jewellery manufacturing operation, illustrating each stage and tool in turn.

Because the model is built in phases, new improvement tools can be added one at a time, blending Lean Manufacturing principles with structured maintenance practices. By aligning Total Productive Maintenance (TPM) with Single-Minute Exchange of Die (SMED), the approach tackles both availability and flexibility factors that matter most in a setting where artisanal craftsmanship must quickly adapt to shifting customer demands.

4.4. Results

Table 1 shows the main results of testing the proposed Lean-TPM operations management model on the case study. After implementation, the efficiency of fulfilling orders went up from 79% to 88%, which is an 11% increase and means that the company can meet delivery deadlines better.

Also, compliance with maintenance activities went up from 67% to 83%, which is a 24% increase and shows that people are following through with their scheduled maintenance tasks.

High changeover times went down a lot, from 5.1 hours to 3.2 hours, which is a 37% reduction. In the same way, SMED time went down from 4.2 hours to 2.6 hours, which is a 38% drop. These results showed that the model worked to fix major problems and improve the performance of the production line that was looked at.

Table 2. Results of applying the proposed model

Indicator	Unit	As-Id	To-Be	Results	Variation (%)
Fulfillment efficiency	%	79%	95%	88%	11%
Maintenance noncompliance	%	67%	90%	83%	24%
High changeover times	Hours	5.1	3.1	3.2	-37%
SMED time	Hours	4.2	2.1	2.6	-38%

5. Discussion

The validation results show that the speed of order processing has improved, the setup times have gotten shorter, and the maintenance schedule is now more closely aligned. These results are like those found in other studies, but this one focuses on the specific conditions of the artisanal jewelry industry. For example, Mejía-Pajuelo et al. [1] found that Lean reforms led to a 20% increase in small and medium-sized businesses in the Peruvian craft sector. This is in line with the 11% increase in fulfilment efficiency here. Durand-Sotelo et al. [2] found that Lean-plus-change management cut lead times in textile SMEs, like the 38% drop in SMED downtime found in this study. Candelario-Cordova et al. [3] found that Lean tools helped micro-textile companies make more products. This supports the idea that standardized methods can help businesses with few employees and a lot of work. Ondra [10] said that combining SMED with TPM makes equipment more effective overall, which is often called the ultimate factory hallmark. This exercise supports that idea. Altamirano et al. [14] found that using Single-Minute Exchange of Die (SMED) and Failure Modes and Effects Analysis (FMEA) together increased Overall Equipment Effectiveness (OEE) by 5.2 percent in a small food-processing company. This supports the model's strategy of dealing with both downtime and changeover delays at the same time.

5.1. Study Limitations

Even though these gains are encouraging, there are several limitations that need to be carefully thought about. First, the framework was tested in a medium-sized jewellery workshop. This workshop's culture, layout, and product mix make it hard to apply the results to other industries or facilities of different sizes. Second, the intervention only lasted four months, which meant that it only showed short-term wins. It did not show whether these wins would last over longer production cycles. The model also relies heavily on frontline buy-in and enthusiasm, which can vary a lot depending on how things are done in different areas or by different managers. The evaluation also only looked at shopfloor metrics, leaving out customer satisfaction scores, return on investment data, and total production cost figures that would have given a fuller picture of the framework's broader economic benefits and trade-offs.

5.2. Practical Implications

These results show that small manufacturers can do several things to work smarter, not harder, while still making their products feel like they were made by hand. First, tools that are usually used on factory floors, like Total Productive Maintenance (TPM) and Single-Minute Exchange of Die (SMED), can be made smaller and more specific for low-volume, highly custom orders without ruining the quality of the work. The 24 percent increase in maintenance compliance shows that even the smallest business can benefit greatly from following a simple, planned maintenance schedule. Also, the 37% drop in time spent switching jobs shows that having written procedures and focused training sessions really works. With these changes, workshops can meet tight deadlines more easily and quickly, even when competitors are breathing down their necks. This step-by-step guide is written in a way that small and medium-sized businesses can understand. It shows them how to make their operations stronger without losing their artisanal spirit.

5.3. Future Works

Drawing on the insights gained during implementation, follow-on research could pursue at least three mutually reinforcing pathways. First, a multi-year, longitudinal inquiry would test whether the recorded gains endure, pairing operational data with financial and customer-satisfaction measures in a single, unified assessment. Second, the model could be piloted in micro-enterprises found in semi-urban and rural areas, probing its robustness and flexibility in contexts that feature sharper resource constraints. Third, embedding low-cost digital tools—such as IoT sensors or cloud-linked dashboards—might sharpen the predictive maintenance algorithm, turning sporadic alerts into ongoing, data-driven conversations between machine and operator. Finally, later iterations could weave in green-manufacturing or circular-economy practices, ensuring that efficiency gains translate into profit and reduced waste, an expectation that increasingly shapes top-tier artisanal markets worldwide.

6. Conclusion

The project shows that using Lean principles alongside Total Productive Maintenance tools helped a gold jewellery factory remove persistent blockages that slowed the operation. Changeover times and instances of missed maintenance dropped sharply, and the on-time delivery rate climbed noticeably, pointing to tangible gains. Together, these results suggest that the blended approach can handle high-customisation production while still protecting the delicate craftsmanship that defines the firm's output.

This research is meaningful because it centres on a niche topic often ignored by scholars: small-scale jewellery-making. Most literature looks at large, high-volume plants, so it treats manufacturing as predictable and fully automated. By tackling a setting marked by artistry and hand tooling, the study fills that gap and proves that standard improvement tools work when blended carefully with the rhythms of skilled craft.

This study provides micro and small jewellery businesses with a clear step-by-step guide for professionalising their workshop functions while preserving the artisan character they value. By pairing planned maintenance with the Single-Minute Exchange of Die (SMED) approach, the model creates a mutually reinforcing system that keeps equipment running and lets production respond quickly to unpredictable customer orders, a feature critical in fast-moving markets. A further benefit is the cultivation of a continuous-improvement mindset, because operators at all levels are encouraged to take ownership of machine care and small, daily gains. Looking ahead, researchers are invited to track the sustainable impact of the model over longer time spans and to add economic and environmental metrics so that its true cost-effectiveness becomes clear. Equally important, adaptations for remote, resource-limited rural workshops should be tested, along with combinations of the framework and low-cost digital tools such as mobile data loggers and cloud production dashboards.

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