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Optimization of the Production Process through Value Chain Mapping, Study of Time and Movements in the Stitching Area

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Abstract:

This study aims to reduce or eliminate workflow constraints, resulting in enhanced operational efficiency by optimizing the performance of the stitching area, reducing manual workload, and minimizing the time required for cleaning markings. This would lead to an increase in productive capacity, enabling the company to meet demand more efficiently. The initiative will strengthen the quality of the production process, increase operational efficiency, and improve the company's profitability. In the long term, the implementation of these improvements will ensure better alignment with the organization's strategic objectives, consolidating its competitiveness in the market.

Keywords — **Optimization, Time and Motion Study, Value Stream Mapping.**

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1 INTRODUCTION

This project aims to analyze and improve the stitching area through the application of industrial engineering tools focused on increasing operational efficiency.

The Time and Motion Study (TMS), widely used in industrial engineering, is a key tool for enhancing the efficiency of production processes. Its value lies in the ability to analyze each activity in detail to optimize human effort, material resources, and energy consumption, and simultaneously improve final product quality. When correctly applied, TMS enables personnel performance to contribute to productivity without increasing workload or assigned time significantly.

Additionally, Value Stream Mapping (VSM) is another essential tool within the Lean Manufacturing approach. It allows for a clear and structured visualization of all stages in the production process, from raw material reception to final product delivery. Its implementation facilitates the identification of value-adding activities and the detection of waste or bottlenecks, aiding in continuous improvement decision-making.

1.1 General Objective

To reduce or eliminate operational constraints in the footwear stitching process, we will apply a Time and Motion Study and Value Stream Mapping, aiming to optimize productivity and reduce processing time to 2 minutes.

1.1.1 Specific Objetives

- Analyze the stitching process to identify improvement areas and detect non-value-adding activities.
- Determine the real production capacity in the stitching area to establish a proper workload balance and optimize available resources.
- Set standard times for each critical activity within the stitching process to reduce unproductive time and enhance operational efficiency.
- Propose continuous improvement strategies based on findings to eliminate or reduce bottlenecks in the stitching area.

2 BACKGROUND AND RELATED WORK

2.1 Related Studies

In various manufacturing industries, identifying and eliminating bottlenecks is crucial for improving operational efficiency and productivity. Companies such as MEGAN face manufacturing issues related to layout optimization, personnel management, and unsuitable working conditions. MEGAN specializes in steel sheet maquila, including laser cutting, punching, deburring, insertion, bending, welding, washing, painting, assembly, and packaging [1].

Similarly, Grupo Dekko de México, located in Ciudad Juárez, Chihuahua, encountered problems in its harness assembly line for office furniture. Producing only 300 units per day against a demand of 440 led to reliance on overtime. Tools like time studies and line balancing were used to optimize production [2].

In Colombia, the company Impactex faced similar challenges. Its men's underwear production line exhibited bottlenecks, unnecessary movements, and long transport distances. Process standardization provided better control [3].

2.2 Theoretical Background

2.2.1 Value Stream Mapping (VSM)

VSM is a powerful tool that identifies value-adding and non-value-adding activities in a process, helping reveal bottlenecks and critical points to guide improvement efforts. VSM focuses on process flow to detect inefficiencies and eliminate waste [4].

In Table 1 are shown the four steps to develop the VSM [5]

Table 1: VSM Development Steps [5]

Steps of VSM
1. Select a critical production área
2. Prepare the current state map • Document key process information • Define and collect data • Provide Information • Map the data
3. Analyze the current state map
4. Create the future state map • Calculate tackt time • Set desired time • Implement Lean Manufacturing Tools

2.2.2 Motion Study

According to [6], a motion study is a systematic procedure that determines the actual time to produce a product by eliminating unnecessary movements.

Motion analysis precedes time standardization. Setting incorrect times would waste industrial engineering effort. Optimizing through motion studies yields automatic and significant cost reductions [7].

Motion study breaks down tasks into basic components, known as therbligs, and analyzes them qualitatively and quantitatively [8].

2.2.3 Time Study

Time study is a work measurement technique used to record task durations and rhythms under defined conditions. It helps establish the standard time required to perform a task [3].

Standard time refers to the time needed by a qualified and trained operator working at a normal pace to perform a specific task. This concept underpins time studies and demands detailed evaluation [7]. Standard time is defined accordingly to equation 1.

$$S_T = N_T(1 + K) \qquad (1)$$

Where:
S_T = Standard Time
N_T = Normal Time
K = Allowances

The International Labour Organization (ILO) provides tables with standard allowances used in the formula [3]

2.2.4 Productivity

Productivity refers to optimizing the production process. It represents the ratio between outputs (goods or services) and inputs (resources used). It is expressed as [9]:

$$Productivity = \frac{Outputs}{Inputs} \qquad (2)$$

To measure the productivity efficiency, equation 3 is used to obtain a percentage parameter:

$$P = 100 * \frac{Observed\ Productivity}{Standard\ Productivity} \qquad (3)$$

Observed productivity is the production observed during a defined period (day, week, month, or year) in a known system (workshop, company, economic sector, department, workforce, country, etc.). The standard of productivity is the base productivity or the previous value observed as a reference [10].

3 METHODOLOGY

3.1 Preliminary análisis

The current VSM and time study of the stitching area was conducted.

In the current state VSM, operations causing bottlenecks were identified. The most disruptive were edge painting and cleaning (119.65 sec), which became the focus of this project. Other significant constraints included "quarter spider and vamp" (116.48 sec) and "unthread and paint edges" (159.96 sec), primarily due to staffing anomalies.

A time study on 24 units (12 pairs) revealed a total time of 1,395.16 seconds (23.25 min). This supports task reallocation for line balancing and process efficiency.

The workday is 9.5 hours with a 30-minute lunch, resulting in 570 minutes/day. With 90% efficiency and 10% plant allowances, adequate time is 30,780 seconds/day (see Table 2).

Table 2: Effective Time Calculation

Effective Time	
Workday	570
Plant Allowance	0%
Available Minutes	570
Efficiency	90%
Adequate Time (Min)	513
Effective Time (Sec)	30780

3.2 Action Plan Implementation

Strategic changes were implemented in the stitching area:

- Reorganization paired each edge folder with a stitcher to reduce distractions.
- Two unused machines were removed to improve space distribution.
- Four stations were upgraded with new UV lamps to improve alignment accuracy during assembly, enhancing precision and reducing errors.

3.3 Analysis of Implemented Changes

A future state VSM and a new time study were developed.

As a first Step, the Takt time was calculated according to a workday, after which it continued with the demand to calculate the available time and the diary demand.

a) Tackt Time Calculation.

Available Time=34,200 sec/day
Daily Demand =100 Shoes.

$$Tackt\ time = \frac{34200\ sec}{100\ shoes} = 342\ \frac{sec}{pair} \qquad (4)$$

This calculation implies that a client is available to buy a pair of shoes every 684 seconds; for this reason, this value is the production target value.

To perform a calculation of the work time necessary to accomplish the Takt time obtained in equation four, a journey of 10 hours with a lunch interval of 30 minutes is established. This consideration gives an available time of 570 minutes, which corresponds to 34200 seconds. Other relevant information is that the workshop has 21 days of labor monthly, with a demand of 2100 pairs per month. Which these data the daily demand is calculated in equation (5).

$$Daily\ Demand = \frac{2100\ units}{21\ days} = 100\ units \qquad (5)$$

The time study conducted in the stitching area was essential due to the modifications implemented in the process. Among the main changes is the elimination of the gel pencil marking, replaced with a UV pencil, which directly impacts operation times. Additionally, a layout reconfiguration was carried out, reorganizing the workstations to optimize the production flow. For these reasons, it was necessary to recalculate the standard times to accurately assess the improvements made and verify whether the changes have effectively contributed to increased efficiency in this stage of the process. In this analysis, the cycle times corresponding to each of the operations involved in the production of 24 individual units, equivalent to 12 complete pairs of shoes, were recorded. The total accumulated time was 1,210.80 seconds (20.18 minutes).

The time study was conducted in cycles, recording 24 cycles per operation exclusively within the stitching area, which involves 41 different operations, as this area represents the primary focus of the study. As a result, a total accumulated time of 23,587.06 seconds for the entire process was obtained, considering the sum of all measured cycles.

4 CONCLUSIONS

During the analysis of the stitching process for model 215, it was identified that the operation "Clean Marking," with a standard time of 82.98 seconds, represented a significant bottleneck in the workflow. This activity involved the manual removal of visible gel pencil markings, which was not only time-consuming but also caused unnecessary wear on the finish of the pieces. As a solution, this operation was eliminated through the implementation of UV markers, which leave an invisible mark and do not require subsequent cleaning. Consequently, a new operation, "Clean Adhesive," with a standard time of 23.79 seconds, was introduced, focusing solely on removing visible adhesive residues after assembly, as shown in Table 3, reflecting the results of the UV marker replacement.

- Reduction in standard time for the operation: (71.3% less).
- Elimination of a non-value-adding activity.
- Improved visual presentation of the footwear with no visible markings.
- Increased operator efficiency by performing a quicker and necessary task.

Table 3: Results of the Marking Change

Indicator	Before (Clean Marking)	After (Clean Adhesive)
Operation Name	Clean Marking	Clean Adhesive
Standard Time (sec)	75.015	23.79
Main Function	Remove visible gel pencil marks	Remove visible adhesive residues
Visual Result	Visually removed manually (slow and risky)	Localized cleaning without damaging material
Impact on the process	Rework, excesive time use	Focused, faster and more effective operation
¿Does it add value?	No	Yes
Result after change	Eliminated from the process	Incorporated as a helpful and more efficient operation

A reduction of **13.21%** in the total process time was achieved. This improvement is significant in industrial environments as it directly impacts line efficiency and reduces time wastage.

- **Before**: 1,395.16 sec (23.25 min)
- **After**: 1,210.80 sec (20.18 min)
- **Reduction of 184.36 seconds (3.07 minutes)**

This represents a direct improvement in the time taken to process all operations, allowing for the production of more units in the same amount of time or reducing the workload per operator (see Table 4).

Tabla 4:Process change results

Indicator	Before	After	Variation
Total Standard Time (sec)	1395.16	1210.80	184.36 sec
Total Standard Time (min)	23.25	20.18	3.07 min
Percentage Reduction	-	-	13.21%
Operations with TE > 70 sec	4	3	25%
Longest Operation	128.13 sec	81.21 sec	36.6%
Defined Stations (Fixed)	1 per operation	1 per operation	-

This study demonstrates the effectiveness of continuous improvement methodologies in artisanal or semi-manual processes, such as footwear manufacturing. It lays the foundation for replicating these same principles in other productive areas of the plant. Additionally, it provides practical tools for monitoring operational efficiency over time. The objectives set at the beginning of the study were achieved, resulting in a more efficient, organized, and controlled process, which directly impacts the company's productivity and competitiveness, as there was a reduction of 167.59 seconds per pair in the stitching area.

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