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Implementation of the Lean Ergonomic Approach to Improving the Performance of a Sausage Process

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Abstract: This study presents the integration of two tools little explored by Small and Medium Enterprises in Mexico: Lean systems with Ergonomics; a case study of application is documented where the main tools used were Value Stream Mapping, SIPOC, Kaizen, REBA Method and NIOSH. As a result, the activities with the greatest risk, waste of time and movements, postures and inadequate procedures were obtained during their operations that delay and affect the flow of the process. After implementing the proposals, a reduction was presented by 33.18% of the cycle time, making the process more efficient. This app can give a new approach to use in improving sME productivity.

Keywords: Efficiency, Ergonomics, Lean Manufacturing, Process Improvement

I. INTRODUCTION

Competition, continuous change and customer demand force organizations to be in constant search of options that allow them to generate greater profitability, productivity and efficiency of their operations; to generate competitive advantages over their competition and to respond to the challenges exposed by the market [1]. However, because of its characteristics, it is common for SMEs to lack a formal structure in the management of their operations, for the same person to perform different functions; this lack of specialization leads SMEs to develop low-level logistics activities due to the lack of technical knowledge and incorrect application of the supply chain concept, having this impact on their productivity [2].

Some Studies[3] comment that one of the most important issues in SMEs is the search for profitability based on production, and over time a myriad of techniques have been developed to meet this great need. However, they mostly do not implement such tools because of the lack of information about their existence and how to implement them [4].

One of the currently recognized tools for analysis and improvement in organizations is The Slender Manufacturing, which allows for a focus beyond operations, its tools are used to reduce waste in human effort and management of operations throughout the supply chain [5]. It is considered a very powerful tool to make improvements in organizations. In [6] mention that if their implementation is carried out correctly, the company will result in the elimination of all operations that do not add value to the product, service and processes, the increase in the value of each activity carried out, eliminating what is not required, reducing waste and improving operations, always based on respect for the worker, just as tangible, measurable and significant improvements in competitiveness will be achieved.

One of the tasks to be done by organizations is the attention to waste known as "human effort" being Ergonomics the ideal tool that allows the analysis and understanding of the interactions of a system in order to optimize the well-being human and the general system, applying techniques to the design of the task and the workstation to adapt them to its user and thus reduce the risk factors, the most common being manual load handling, postural load and repetitiveness. Investigations[7] mention that some research has extensively analyzed the impact of slender thinking on workers' health and safety, and have shown that musculoskeletal disorders (MSDs) lead to a loss productivity due to a higher rate of absenteeism and injuries. In this way the integration of Ergonomics during the implementation of lean manufacturing has the potential to achieve improvements in productivity and at the same time improve working conditions.

1.1 Case Study

In the organization under study, efficiency represents one of the most important elements of analysis, it is for this reason that different projects have been carried out in the processes, with the benefit of saving unnecessary movements and reduction in waste, up to 6 hours. However, risk situations have occurred to the operator, and their consequences have been translated into 2017 statistics, where lumbar injuries, carpal tunnel syndrome, epicondylitis and shoulder pains are recorded; which resulted in casualties to the efficiency of the processes resulting from not working under the required conditions (slips, falls, fatigue, back pain, shoulders,

necks) due to forced postures and manual mishandling of loads,) causing illness, incapacity, descending the quality of life of employees.

Faced with this situation, the search for improvements in the organization was undertaken, in order to achieve a better performance of the processes; and the following research question was asked: To what extent will the implementation of the Lean Ergonomics Approach improve efficiency in your operations?

1.2 Literature Review

Studies [8-9] agree that the application of each Slender Manufacturing tool should take into account the direct correlation it has on the working conditions of the operator; in such a way that the combination of Lean thinking and ergonomics results in a system where not only the worker is more efficient, but also is safe and comfortable while trying to produce the best possible product. For their part in[10], comment that the integration of these approaches (human factors and ergonomics) into lean systems, allows users and senior managers to implement in their daily work routines a continuous improvement approach and internal collaboration. Studies [11] presents an analysis of different studies in which lean manufacturing tools and ergonomic methods for process valuation have been implemented, see table 1.

Table 1. Slender Manufacturing-Ergonomics Research Overview

Authors	I am a student	Name
Koykoulaki, (2014)) [12]	Occupational health and safety	The impact of lean production on musculoskeletal and psychosocial risks: an examination of socio-technical trends for 20 years.
Cullinane, Bosak, Flood, and Demerouti, (2014)[5]	Philosophy	Design of work under Lean Manufacturing and the quality of working life: Perspective of a demand for work and resources.
Morse, (2014)[13]	Mechanical and Industrial Engineering	Evaluation of Lean's impact on the ergonomics, safety and job satisfaction of employees in manufacturing.
Arezes , Dinis , and Alves , (2014)[14]	Production and System	Ergonomics in the workplace in lean manufacturing environments: a review of literature.

II. METHODOLOGY

This research is observational, transversal, non-experimental, 100% of the operators in the sausage process, without considering the worker that he is covering any disability, absence or illness. The following describes the procedure for the development of research, techniques, tools and tools used for the collection of information.

2.1 Procedure

The general procedure is defined in a first phase as analysis of the current situation under the approach of the slender system and a later phase with the determination of corrective actions and risk reassessment, the following is described:

Phase 1. Preparation of VSM Current

At this stage, operations are analyzed through the Value Stream Mapping (VSM) tool to understand the current process situation, where the following elements should be considered:

- Elaboration of Process Diagram. Analyze the supply chain in detail of the process using the SIPOC Diagram.
- Identification of Ergonomic Risks. Identify risks in each of the process operations using the BRIEF/BEST Method, determining their risk condition.
- Ergonomic Risk Assessment. Evaluate activities on the workstation using ergonomic methods according to the results of risk identification in order to define improvement options that reduce risk and obtain acceptable levels of exposure for Worker.

Phase 2. Preparation of future VSM.

At this stage, ergonomic improvements will be integrated into a future VSM to compare previous efficiency with current efficiency in process operations and assessment of the ergonomic hazards encountered; consideration should be given to:

- Design of Improvement Proposals. Establish improvement actions using lean manufacturing tools to reduce waste that occurs during the process, considering ergonomic conditions and factors.
- Ergonomic Risk Assessment. Evaluate activities on the workstation with the implementation of improvements to verify changes.

2.2 Materials

- Camera
- Ergo Soft Pro 4.0 Software
- Microsoft Visio Professional 2016

III. RESULTS

Risk Identification and Assessment

Risk identification was carried out using the BRIEF/BEST method, according to the results obtained in all the activities of the process has to be carried out an ergonomic evaluation, two activities of medium risk were found (1:Fill hopper and 3:Prepare molds), two activities of high risk (4:embut and regret, and 6:caged), and two activities of very high risk (2:Prepare machine and 5:Molder and Cover), see table 2. These results and operation characteristics determined that the methods they apply for risk assessment are REBA (Rapid Entire Body Assessment) for postural load assessment (see Fig. 1) and NIOSH for load handling assessment (see Fig. 2).

Table 2. Risk identification BRIEF/BEST method

Process	Activity	Risk Value	Priority
Inlay	1	27	Middle
	2	52	Very High
	3	26	Middle
	4	36	High
	5	72	Very High
	6	36	High

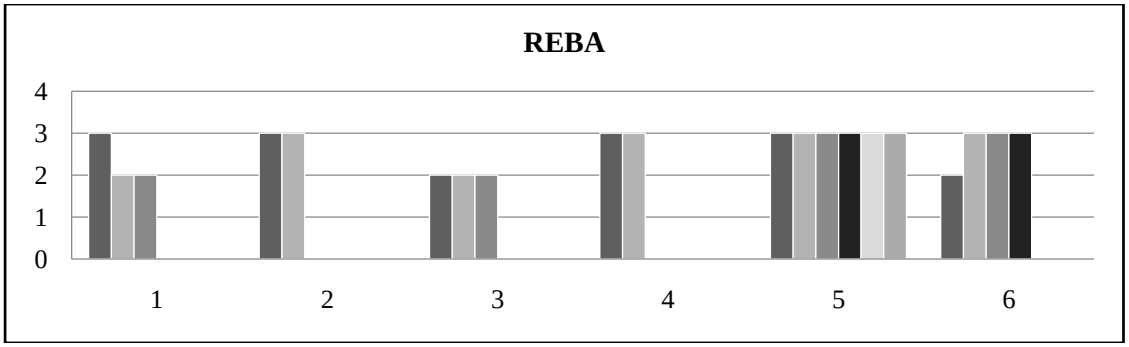

Figure 1. Evaluation of activities with REBA method

The action levels according to the REBA method are 1 x Not required; 2 to 3 may be necessary; 4 to 7 ' Necessary; 8 to 10 ' Needed soon; 11-15 - Immediate performance.

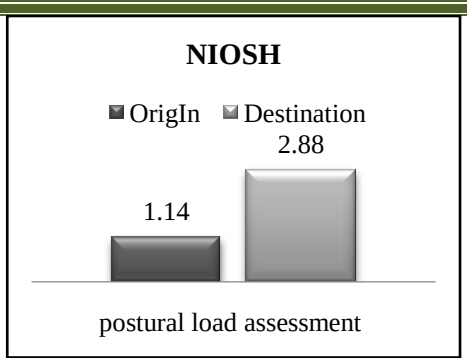

Figure 2. Evaluation of activities with NIOSH method

According to the NIOSH method, three risk zones can be considered according to the IL values obtained for the task. Limited Risk (IL 1). Moderate increase in risk (1st IL 3). Increased risk (IL s 3).

Finally, the evaluation represented the level of risk and the score handled by each method (table 3). In addition, all the ergonomic risks of the process obtained from the methods used in all activities performed in the processing of smoked sausages were graphically shaped using the Value Stream Mapping tool.

Table 3. Risk Representation

Niosh	Reba	Risk
1<	1-3	Under
1-3	4-7	Middle
>3	8-15	High

Preparation of VSM Current

The VSM represents the current situation of the sausage process divided into its operations, it indicates how the process flows, the requirements and the flow of customer information (cooking) to the supplier (massage). In addition, it shows the result of the ergonomic evaluation for each activity and its level of risk. See Fig 3.

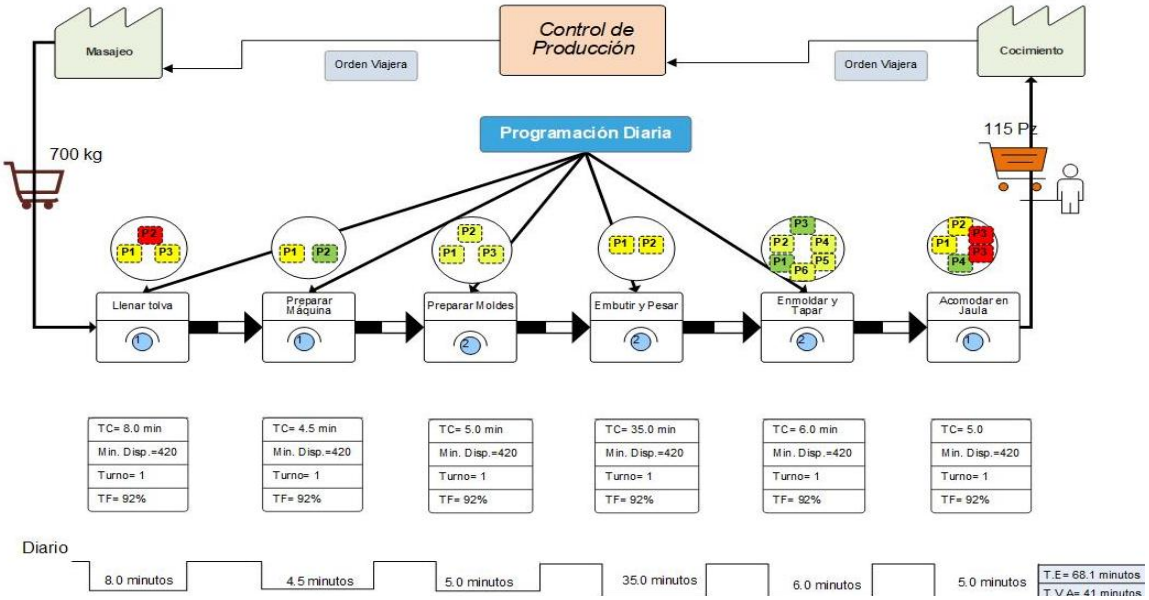

Figure 3. VSM Current with Ergonomic Assessment

Design of Improvement proposals.

The process has six activities, which were divided into a total of 21 positions. The results of the evaluation showed that 4 postures are low risk, 14 are medium risk and the rest are critical with a high level of risk, which must be improved to avoid possible injuries, working diseases in the future. From the above arises

the need to generate proposals that help improve the process, as well as reduce risks. The evaluation found critical positions that can damage the health of the operator, so you have the following proposals regarding positions by activity:

Fill hopper: To decrease the level of risk in the three postures, an adaptation to the load handling equipment in which the mixture is transported is transported to be filled and thus that the height is adjusted to the operator in such a way that it does not have back bending.

Prepare molds: Three mid-level postures were observed, so it is proposed that the pallet where the molds are placed is at an optimal height for the operator.

Cage accommodate: It was observed that in positions 1, 2 and 4 a medium risk level and posture 3 with a high risk level was observed, suggesting the use of a poka yoke to delimit the accommodating of the materials required; it is important that the operator pivots at the time of performing this activity, in this way there will be no angle of action and this avoids risk of any injury.

With the application of these actions the process was reassessed with the same ergonomic methods, but now with corrections in the positions of the operators, see Figure 4.

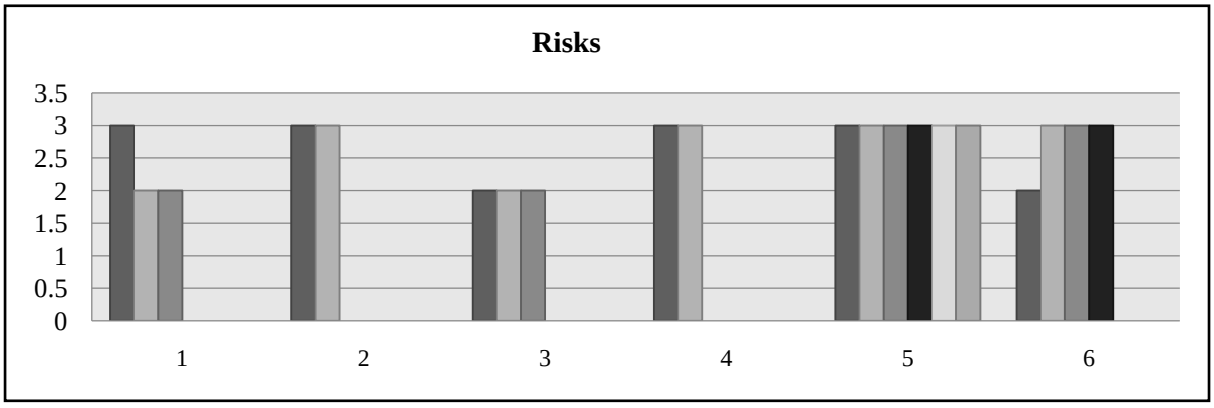

Figure 4. Risks of the process are re-evaluation, using the REBA Method.

The reassessment reduced all risks where previously medium and high levels were previously and are now low risk.

Development of the VSM Future

The following represents the improved future VSM including the proposals, plus the new ergonomic evaluation of the process was added, see Figure 5.

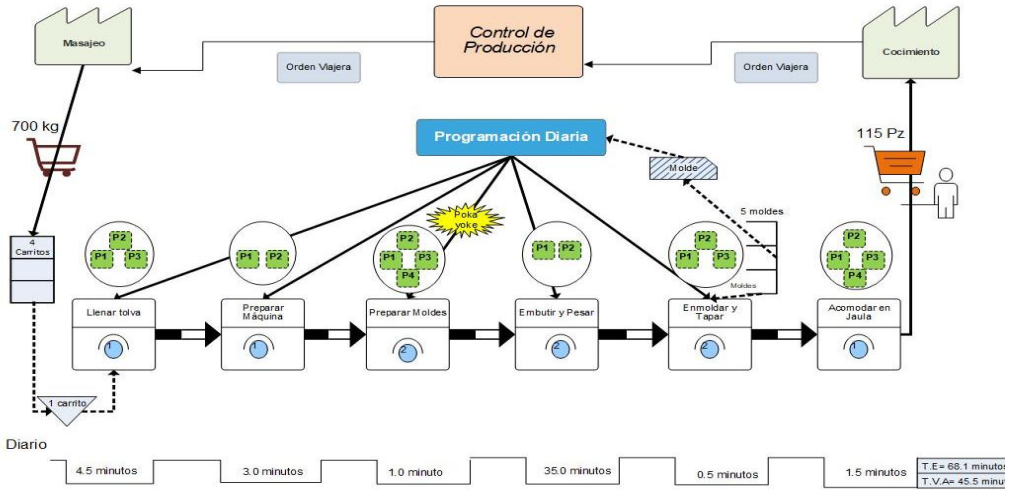

Figure 5. VSM Future with ergonomic assessment

The efficiency of the process was calculated considering the reduction of time in the activities, which were considered by subtracting the time of the activities of each stage of the process carried out by the operator

and which do not add value during the process of a batch. A time reduction of 22 minutes is calculated, which in percentage represents 33.18% for a batch of 115 pieces.

IV. DISCUSSION

As Mentioned by [15] the integration of the Lean Ergonomics approach into work environments into a tool like the Value Stream Mapping shows us the current conditions of each stage of the process, and determine all those activities that do not generate value (the risks that may exist when performing an operation; a) work postures, b) weights/excessive force, c) physical load, and could also be considered the Psychosocial dimensions: a) Demands, b) control, c) communication, etc.). However, to date, the increased use of this tool has been used is to focus on waste to identify workflow problems and develop an improved workflow; this being an area of opportunity for organizations, as argued by [16-17] conclude that the integration of Ergonomics- VSM facilitates the development of an action plan that can result in greater organizational sustainability compared to traditional VSM.

V. CONCLUSIONS

Based on the study and results of the Lean Ergonomics project applied to the sausage process, the objective of increasing efficiency through Lean tools and ergonomic assessments is met, improving on average 33.18% the operating times of each activity, in turn decreases and / or eliminates the level of risk, allowing the operator to work under appropriate conditions and do his work safely. Implementing the improvements comes at a cost, however, not meeting the needs of the process and the human factor generates accidents, diseases that lead to days of disability and even death, causing a higher cost to the organization and damage to the operator. Lean Ergonomics is a novel tool with little information, so with this project it was possible to contribute a little more information to the research about the application of this tool that is obtained by integrating lean manufacturing and ergonomics, which together contribute to the reduction of waste in human activities that are considered as waste, making a process more efficient and free of ergonomic risks.

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