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Development of Lean Manufacturing Tools in Environments Automated Systems in the Has200 Manufacturing Cell of the Universidad Libre De Colombia Bosque Popular Headquarters

MBA Ever Ángel Fuentes[1], John Linares Forero[2], Erick Alexander Tello Garcìa[3]
1 (Industrial engineering program, Engineering Faculty, Universidad Libre, Colombia)
2 (Industrial engineering program, Engineering Faculty, Universidad Libre, Colombia)
3 (Industrial engineering program, Engineering Faculty, Universidad Libre, Colombia)

ABSTRACT:
The industry automation systems, generate a great models, method and acceptance programs demand for the implementation of productive process. Over time, each method generates tools, the importance of knowing how to use them efficiently, gives a quantitative and qualitative benefit for the participating process in the products development. [1]
The way of applying tools such as: Lean Manufacturing, entails productivity, changes in the management system, never-ending improvement, optimal organizational environment, for human resources, real exhaustive assessment which can be applied in different ways in the creation process of goods and services. Consequently, in this research work an analysis of HAS200 Manufacturing cell, was done, where the implementation of 5S, Andon, Kaban, and AMFE was validated in automat environments which enable an added value in the process, reduce operation time and increment competitivity in the industry.
Keyword: *automation, models, process, productivity and management*

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I. INTRODUCTION

International organizations are in a competent field to develop automation and environmental processes, which lead the way to technology in order to control and keep the productive process under observation. However, searching for models for the encouragement of appropriate strategies to automation fields, plays an important role for engineers.

Industrial automation dates back from time immemorial. Back in those days, machines were used in construction sites, sieges and time changes, meaning, artefacts used as management of construction material, traction equipment, pulleys and levers, systems.

Industrial revolution impacted with the automation, amongst its most visible cases, there are: textile companies, mining companies, steam engines and steelmaker industry. One of the most outstanding inventors was Mr. Joseph Marie Jacquard, who invented an automatic loom, controlled by pierced cards. Over time, different studies were made, which put in evidence the breach between technological development and the creation of knowledge which generates different levels of growth local and international.

Lean Manufacturing has been opening a path for over half a century, with the industry coming 4.0, breaking paradigms on the production models, which tend towards an industry with more awareness of our planet environmental resources, in which science and technology are each day, more efficient and faster.

It was born specifically in 1939 in Japan, inside automotive industries of the brand known worldwide as Toyota, such event was named as “Toyota Production System” [2].

In United States the milestone of Lean Manufacturing was conceived by experts of The Vehicle and Mobility Innovation Program (PVMI) at the Massachusetts Institute of Technology (MIT) by the end of the 80’s as an agile, flexible, innovate and efficient production system [3].

As part of creation of knowledge, four tools of Lean Manufacturing were used, in automat environments through a simulation lab that validates their behavior as well as stablish constant improvement plans.

II. METHODOLOGY

In order to accomplish defined objectives, it was necessary to establish different methodologies which determined the activities to develop as well as the mechanisms to use to collect needed data.

For the first objective, a diagnose methodology was used to enable the assessment of important elements for the simulation in the automation programs, which took place at the Universidad Libre HAS200 Manufacturing cell, which counts with 10 automat cells and semiautomatic [4]. Consequently, in order to carry out the assessment of the simulation processes of the current situation, information was obtained directly from interviews conducted to people in charge of each area, checklists, flowcharts, data analysis, 8 + 1 waste area, which could be found at HAS200 (Imperfections, overproduction, time, untapped talent, transportation, inventory, movement and extra processing).

Based on the information collected, a matrix was made, DOFA, thus, enabling an internal and external analysis, identifying strengths, weaknesses, opportunities and threads.

For the second objective aimed to determine what Lean Manufacturing tools could be used with automat machine in the production simulation processes, a comparative chart was implemented, based on the collected initial assessment, evaluating 21 tools, among which four were selected (5S, ANDON, KABAN, and AMFE), as a result of assessment implementation of Lean Manufacturing tools, that was done.

Afterwards, in order to accomplish the third objective, focused on the use of the four tools, the development of the first tool 5S was carried out through a program with a monitoring and evaluation system of the automatization and implementation in the industry; for the second tool ANDON, an inspection was made of the cell spacewhere HAS200 contains an Andon system per workstation, nevertheless the supervision is reinforced through installing a device with four different alerts documented on four time frames; third tool KANBAN it is developed in an area of the automatic machine, where participating people will be able to access datasheet or elements containing assigned tasks, optimizing timing. Lastly tool AMFE which enables the assessment and improvement of different errors that arise throughout the operation [5], [6].

For the fourth objective a validation of Lean Manufacturing cell tools was made, as well as the exposition of methodology formats where different results were obtained, which will contribute to the use of research work based on consolidated experience [7].

To conclude, impact social analysis was done, where main social benefit, cost quantifiable and no quantifiable were determined.

III. RESULTS

Universidad Libre's Engineering Faculty counts with different labs, which seeks to complement the comprehensive education of future professionals, manufacturing cell outstands, made out of simulated elements for the developments of automat activities; this space, counts with a four-meters lab approx. In the middle part of the room, you can find the HAS200, made out of 10 modules, where: HAS200: 201, 202, 203, 204, 205, 206, 207, 208, 209, 2010 are participant.

For the manufacturing HAS200 cell functioning, it is necessary an orientation, standardize instructions through work guidelines and an implementation of preventive and corrective maintenance.

Basic guidelines were stablished to study in more detail, its proper use:

- Do a short orientation
- Prepare the team
- Check electric and pneumatic connections
- Stablish time and people required for the simulation
- Present its respective guideline
- Present pertinent parameters, depending on the simulation, for its development
- Presence and supervision of lab assistant
- Program preventive and corrective maintenance

It must be taken into account that the HAS200 simulates automatic and semi-automatic processes, as well as, cell pneumatic components are an essential part of each module mastering.

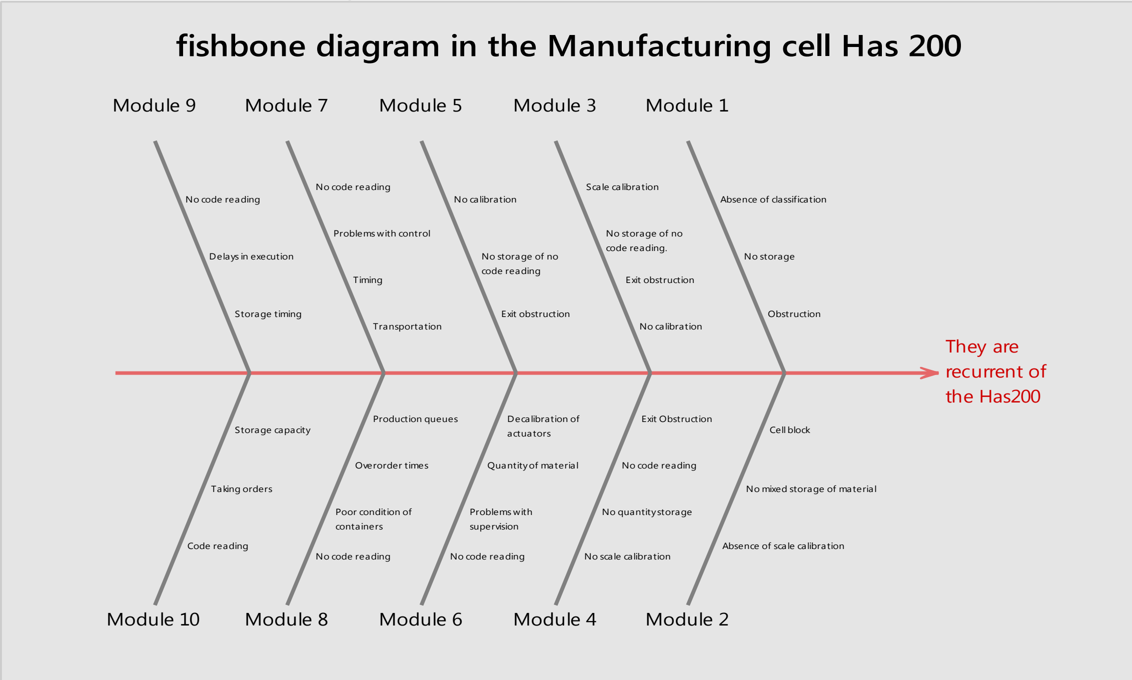
Part of the evidence from the assessment allows to stablish the cell operation parameters:

- It has normal wear according to its manufacturing model
- On storage bins the cell fails to recognize barcodes
- On some occasions the actuators tend to get clogged due to the dimensions of the product
- The symmetry of the material may vary
- In the separation of the material the machine has a high margin of error

- Scales are sometimes not very accurate
- The keypads have got wear that prevents sending orders
- In some sections of the band, the container can derail or remain in an obstruction zone
- The cell can be decalibrated by the pressure regulators

In figure 1 we can observe the cause effect diagram as part of the assessment analysis.

Figure 1. Cause effect Diagram Cell HAS200



Source: The authors, 2022.

In figure 2, we can observe matrix DOFA which enables to identify internal and external elements that affect the cell functioning.

Figure 2. Matrix DOFA

WEAKNESSES

- Material waste
- Color coded material with errors
- Modules with material waste
- Production delays
- Poor performance of automated environments development
- Lack of awareness of tools to process automatization
- Compressor failures
- Electric system malfunction
- Code bar reading malfunction
- Failure in the filling and weight of the cubes
- Button wear failure
- Obstruction of transportation band
- Scales calibration malfunctioning
- Undated master computer
- Low rate of use of resources and HAS200 cell
- Lack of cell training

THREADS

- Lack of preventive maintenance of HAS200 Manufacturing cell
- Lack of corrective maintenance of HAS200 Manufacturing cell
- Lack of electric maintenance
- Lack of hydraulic maintenance
- Lack of pneumatic maintenance
- Lack of compressor maintenance
- Lack of preventive maintenance

STRENGTHS

- HAS200 manufacturing cell
- Several ways of operation, Manual and automatic
- Test Lab

OPPORTUNITIES

- Real process simulation
- Real production operation training
- Implementation of production models
- Analysis and comparison of results of operations
- Knowledge of new production technologies

Source: The authors, 2022.

In this regard, according to studies carried out and technical comparing to other experiences, it is proposed to work with the four tools of Lean Manufacturing in the HAS200 manufacturing Cell for the simulation production processes (see figure 3).

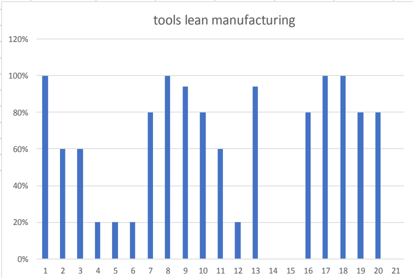
Figure 3. Comparison chart of implementation evolution of Lean Manufacturing tools

HAS200 MANUFACTURING CELL

HAS200 MANUFACTURING CELL

herramientas de lean manufacturing		celda 1	celda 2	celda 3	celda 4	celda 5	celda 6	celda 7	celda 8	celda 9	celda 10	TOTAL NIVELES 1-5	porcentaje%
ANDON	Alerting system of visual form	5	5	5	5	5	5	5	5	5	5	50	100%
SMED	Continuous Improvement tools that seeks to reduce timing	3	3	3	3	3	3	3	3	3	3	30	60%
VALUE STREAM MAPPING	Value flow map, analyst of data and material	3	3	3	3	3	3	3	3	3	3	30	60%
HEIJUNKA	Readiness of the production program by volume and mix of products	1	1	1	1	1	1	1	1	1	1	10	20%
KPI	Lean manufacturing or clean production	1	1	1	1	1	1	1	1	1	1	10	20%
KABAN	Visual method to control production	1	1	1	1	1	1	1	1	1	1	10	20%
GEMBA	Workstation	4	4	4	4	4	4	4	4	4	4	40	80%
5S DEL LEAN	Process and management of workstation	5	5	5	5	5	5	5	5	5	5	50	100%
JUST IN TIME	Just on time on request	5	5	5	5	5	5	5	5	5	2	47	94%
TOTAL QUALITY PROCESS	organizational management approach	4	4	4	4	4	4	4	4	4	4	40	80%
POKA YOKE	Avoid human errors in mechanisms	3	3	3	3	3	3	3	3	3	3	30	60%
TASK AUTOMATION	Automatic relation of actions inside production	1	1	1	1	1	1	1	1	1	1	10	20%
TOTAL FRUITFUL MAINTENACE	set of actions destined to secure availability	5	5	5	5	5	5	5	5	5	2	47	94%
SIX SIGMA	Procedures improvement	4	4	4	4	4	4	4	4	4	4	40	80%
JIDOKA	Auto control of quality	5	5	5	5	5	5	5	5	5	5	50	100%
AMFE	Methodology used to predict failures in a product in design stage	5	5	5	5	5	5	5	5	5	5	50	100%
KAIZEN	Continuous improvement analyze procedures	4	4	4	4	4	4	4	4	4	4	40	80%
SPP	staff participation	4	4	4	4	4	4	4	4	4	4	40	80%
		300%										624	

To supervision and implementation of automated systems		
LEVEL 1	Non applicable to the module components	20%
LEVEL 2	it is implemented in a superficial form to the cell module	20%
LEVEL 3	Relative intervention of applicable cell components	20%
LEVEL 4	Compromise and nurture the participant elements of the cell	20%
LEVEL 5	Non-stop intervention of tool in the cell module	20%
		100%

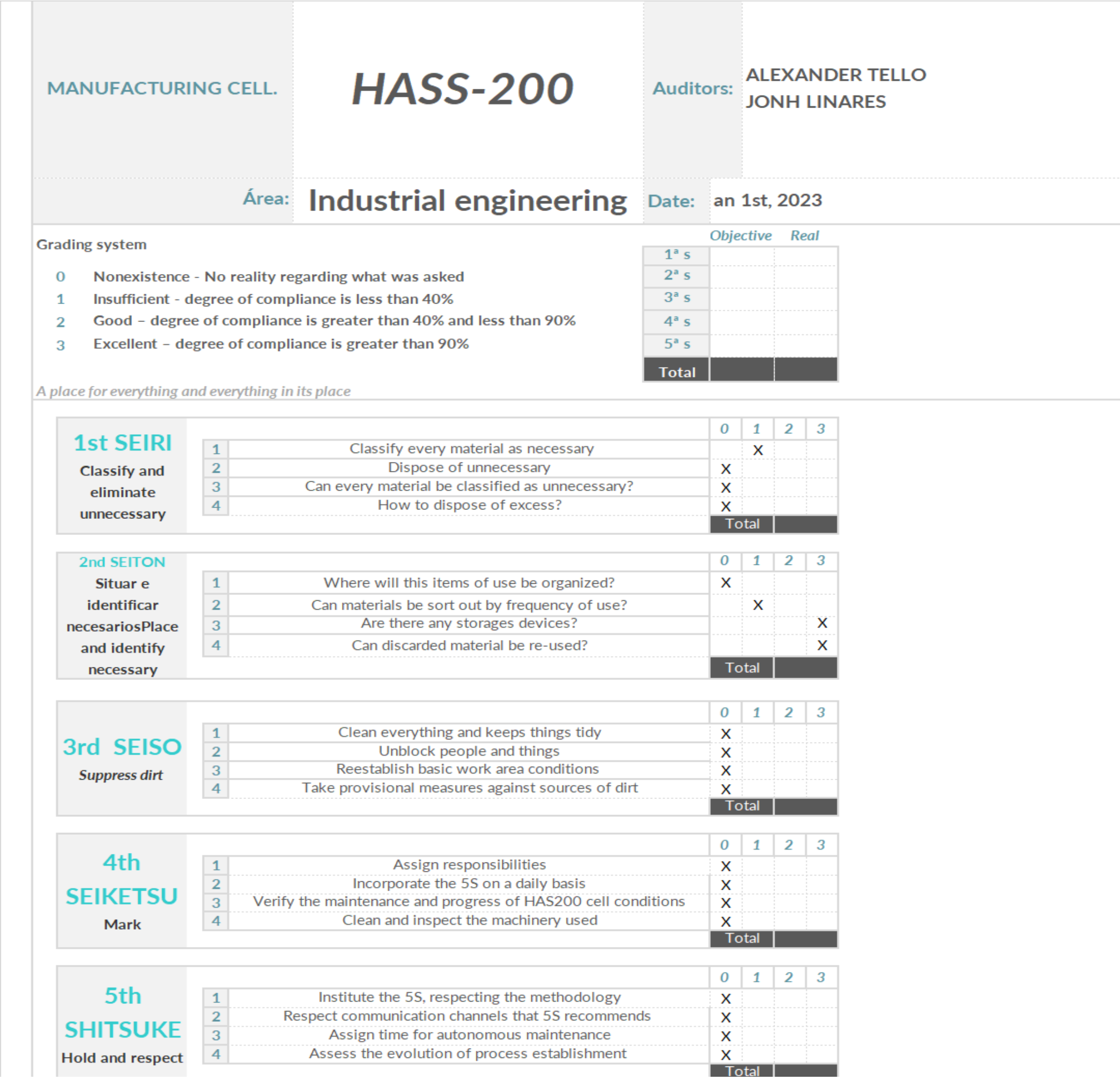


Source: The authors, 2022.

The 5(S) Japanese management technique, whose impact on companies and people, has led to its implementation in the vast majority of companies. Its main characteristic is to become a method that maintains and improves the conditions of organization, order and cleanliness, parallel to this it develops optimal working conditions in work environments.

Figure 4 shows the proposed monitoring model that allows evaluating the evolution of the application of the 5s in automated environments.

Figure 4. 5S Monitoring Model



MANUFACTURING CELL.	HASS-200	Auditors:	ALEXANDER TELLO JONH LINARES
Área:	Industrial engineering	Date:	an 1st, 2023

Grading system

0	Nonexistence - No reality regarding what was asked
1	Insufficient - degree of compliance is less than 40%
2	Good – degree of compliance is greater than 40% and less than 90%
3	Excellent – degree of compliance is greater than 90%

	Objective	Real
1ª s		
2ª s		
3ª s		
4ª s		
5ª s		
Total		

A place for everything and everything in its place

1st SEIRI Classify and eliminate unnecessary			0	1	2	3
	1	Classify every material as necessary		X		
	2	Dispose of unnecessary	X			
	3	Can every material be classified as unnecessary?	X			
	4	How to dispose of excess?	X			
			Total			

2nd SEITON Situar e identificar necesariosPlace and identify necessary			0	1	2	3
	1	Where will this items of use be organized?	X			
	2	Can materials be sort out by frequency of use?		X		
	3	Are there any storages devices?				X
	4	Can discarded material be re-used?				X
			Total			

3rd SEISO Suppress dirt			0	1	2	3
	1	Clean everything and keeps things tidy	X			
	2	Unblock people and things	X			
	3	Reestablish basic work area conditions	X			
	4	Take provisional measures against sources of dirt	X			
			Total			

4th SEIKETSU Mark			0	1	2	3
	1	Assign responsibilities	X			
	2	Incorporate the 5S on a daily basis	X			
	3	Verify the maintenance and progress of HAS200 cell conditions	X			
	4	Clean and inspect the machinery used	X			
			Total			

5th SHITSUKE Hold and respect			0	1	2	3
	1	Institute the 5S, respecting the methodology	X			
	2	Respect communication channels that 5S recommends	X			
	3	Assign time for autonomous maintenance	X			
	4	Assess the evolution of process establishment	X			
			Total			

Source: The authors, 2022.

The main phases are established by 5 words that start with the letter S [8], which must be developed in order to impact not only the companies but also the life of each one of the collaborators [9]:

- SEIRI (Classify and eliminate): Classification of necessary and unnecessary materials
- SEITON (order): Classifying and identification of this materials
- SEISO (Clean): Workstations, or workplace, tidied up, good and optimal conditions
- SEIKETSU (standardize): Effectively monitor environments visually for anomaly control
- SHITSUKE: (discipline): The norms established as the foundation of discipline and order

The Andon is one of the Lean Manufacturing tools that allows to visually generate a supervision, alert and improves control of the production processes of the automation for the lines of productive work [10].

Figure 5 shows the Andon evaluation and improvement plan applied in the HAS 200 manufacturing cell, where the philosophy of this tool is applied through the color display of its position.

Figure 5. Andon Model

HAS200 MANUFACTURING CELL												
LEAN MANUFACTURING TOOLS		**ANDON MAINTENANCE**	**Module 1**	**Module 2**	**Module 3**	**Module 4**	**Module 5**	**Module 6**	**Module 7**	**Module 8**	**Module 9**	**Module10**
ANDON	**MAINTENANCE**	faulty module on the conveyor belt	3	1	1	1	1	1	1	1	1	1
		Faulty module on the scale	4	2	2	2	4	4	4	4	4	4
		Faulty module on classification of product	2	4	4	4	4	4	4	4	4	1
		Faulty module on code bar reading	1	1	1	1	1	1	1	1	1	1
		Faulty module on manual controls	3	3	3	3	3	3	3	3	3	3
		Faulty module on compressor	1	1	1	1	1	1	1	1	1	1
		Faulty module on electrics	1	1	1	1	1	1	1	1	1	1
		Faulty module on mechanics	1	1	1	1	1	1	1	1	1	1
		Faulty module on quality process	4	4	4	4	4	4	4	1	1	1
		Failure on the quantity of product	4	4	4	4	4	4	4	4	4	4
		Failure on the kind of product	4	4	4	4	4	4	4	4	1	1
	OPERATORS	Eliminatewasteorchanges	4	2	2	2	2	2	2	2	2	2
	SYSTEM	Failureonthepurchaseorder SOFTWARE	1	1	1	1	1	1	1	1	1	1
		TOTAL										

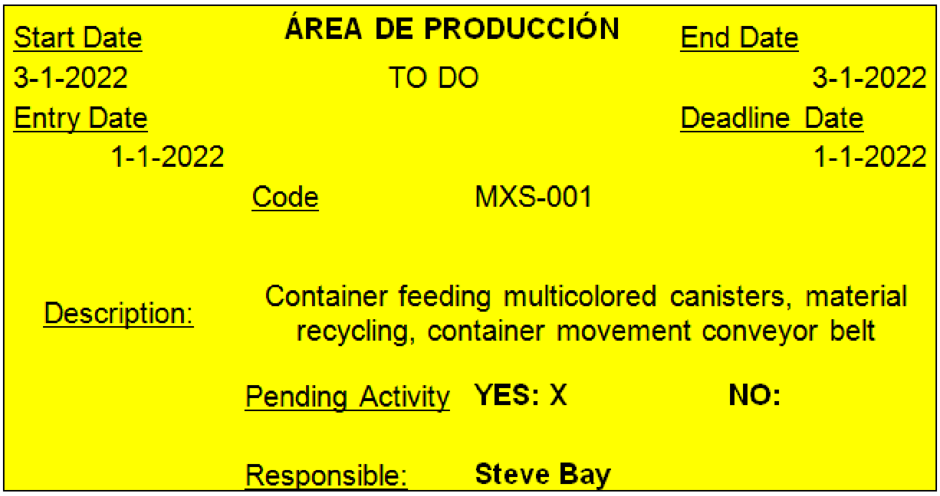
Source: The authors, 2022.

The application of this tool allows, through parameters and visual devices, to facilitate control monitoring in production processes, providing information that is used to improve activities.

For the application of the KANBAN methodology developed in Has200, the number of personnel involved in the simulation must be established [11].

The card holder methodology must have a space in the simulation area for each module, which will have production indications embodied in KANBAN cards, as a guide for its activities in the simulation process, this in order to anticipate delays to the time of machine manipulation [12].

Figure 6 shows an example of a KANBAN card proposed for the HAS200 Manufacturing Cell



Source: The authors, 2022.

Finally, the AMFE tool was developed, in which different parameters that generate failures that can be of different levels were analyzed. The objective is to establish contingency plans or programs that allow the description of all the steps to follow, modes, effects and potential causes of failure are documented, current control systems are identified, evaluation criteria are determined for each failure, each failure mode is calculated and with this the risk priority number is constituted. Decision is taken, which will be applied to correct activities that does not work normally, this is in order to be able to counteract the failures that appear and guarantee the proper development of the activities [13].

IV. DISCUSSION

According to the research proposed by the authors, Colombia due to its productivity levels of the last twenty years and taking as a reference other success stories in Lean Manufacturing in the metallurgical sector that has allowed better results in inventory management and better physical layout of its plants; more defined areas for signage, due to the use of the 5S and TPM of the Lean philosophy; where it is possible to reduce materials and unnecessary distances in the work areas, better working conditions and preventive processes that optimize the wear of tools and equipment; reducing cost without sacrificing quality and productivity.

Clearly, Lean Manufacturing is a philosophy that has allowed progress in the reorganization and optimization of systematization processes at the business level, with the implementation of tools of interest in the industry, combining efforts to achieve an increase in companies in their degree of efficiency in the development of processes and minimizing waste, understood as the activity that does not add value to the company [14].

Based on the research, it is important to mention that the key to success lies in the correct application, in putting all the willingness and commitment possible on the part of all the parties involved, and in not resisting change, since cultural changes generally are presented as an obstacle to improvement, it is not easy to try to impose a new way of thinking on people.

In general, the companies that have put Lean Manufacturing into practice as their work philosophy, as can be seen through the investigation process carried out in this research work, have experienced significant reductions in the areas used, production costs, inventories, costs of quality, purchase costs and Lead time, while increasing their productivity, flexibility, improving quality, use of staff, and the use of space and machinery [15].

V. CONCLUSSIONS

The investigation carried out made it possible to identify the most appropriate Lean Manufacturing tools for automated environments similar to the Has200 cell that allow optimizing times, workflows, adaptations of the organizational environment, alerts, and evidence of continuous improvement.

The importance of Industrial Engineering tools in the development of this project is highlighted, as these are the basis for the execution of each stage, thus providing solid foundations to establish the strategies that will lead to the standardization of the process in the industry.

The implementation of Lean Manufacturing allows the solution of problematic situations in companies and contributes to the generation of educational materials for the training of operators, suppliers and other groups of people related to the work of companies [16].

Finally, to achieve the standardization of processes efficiently, it is necessary to implement the results of this research in the selection and development of the different Lean Manufacturing tools, which will lead to increased productivity, optimal organizational environments for human resources and automation.

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