1 Introduction

When discussing about Lean manufacturing and layout, it is common to associate to cellular layout considering its main characteristics of positioning all necessary resources for the assembly of a product part and, combining all these parts, the final product. However, accordingly to the company's context, cellular layout can not be the selected one, even if the main driver is lean manufacturing.

For this paper, the industry used as a study case is a German multinational which is in the welding segment and has a factory in the state of Rio de Janeiro, Brazil. Divided into two pavements, the machining and packaging sectors as well as the warehouse are on the first floor and the assembly line in the second, being necessary transporting products, parts, and components through an industrial elevator.

On the second floor, its assembly line is divided and identified by signs of three product lines – Meta Inert Gas/Metal Active Gas (MIG/MAG), Tungsten Inert Gas (TIG) and Robot torches and cables. There are pre-assemblies' cells of components and cables which are used in assemblies' cells of torches or are sold as spare parts. Despite being divided by these signs, the positioning of cells does not follow completely this separation. This fact, besides visually not being in accord to the signs, results in the need of operators move themselves between cells to arrange finished products or gather components.

These shifts are considered movement times and are included as non-productive hours in the factory's productivity indicators. These indicators are calculated considering productive hours and hours when employees remain without Production Orders (PO). Since operators invest time in movements, which are non-productive hours, the results of the indicators decrease by 10% in relation to the hours available.

In addition, it was identified by times studies that the assembly times are correct compared with the effective time invested by employees. However, the total production time is increased in 28% by movement times for torch assembly, caused by the current layout. Therefore, this paper approaches the question of redesigning layout using Lean manufacturing as the main driver.

2 Bibliographic research

The objective of this stage was understanding concepts related to lean manufacturing and layout and lean tools indicated for designing layouts. Also, identifying methodologies for layout planning and which one is the most suitable considering lean manufacturing as the main driver.

The procedures used in the literature review were based on the systematic literature review model (Cauchick et al., 2018) composed of five stages: search, organization, and selection, reading, annotation and critical analysis and writing.

2.1 Lean Manufacturing

In the post-war period between 1948 and 1975, the Toyota Production, Lean Production or Lean Manufacturing System began to be developed mainly by Toyota's vice president, Taiichi Ohno, with the aim of recovering the Japanese market from the devastating remains of the Second World War.

For Wilson (2010), the concept of Lean goes far beyond physical installations and cost reduction. It also involves people, who work with more confidence and ease than in a traditionally reactionary and "chaotic" environment. Lean Manufacturing or Lean production, according to Dennis (2009), "represents doing more with less - less time, less space, less human effort, less machinery, less material - and, at the same time, giving customers what they want".

According to Dailey (2003), waste is the flow of information or activities that do not add value - cost without a compensating benefit. Ohno (1997) classified waste (or losses) into seven classes: by overproduction, by time or waiting, by transportation, motion, processing, defects and by inventory.

Throughout the development of Lean philosophy, tools were elaborated with the aim of eliminating the seven classes of waste, helping directly or indirectly to reduce costs by eliminating activities that do not add value to the product, in addition to respecting the five principles of Lean production.

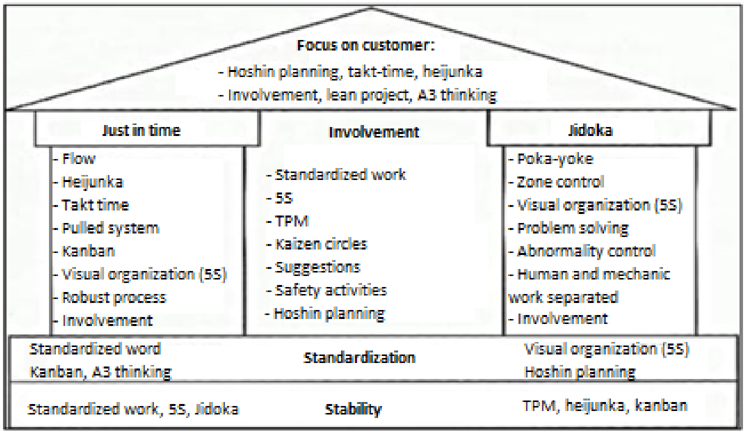

Figure 1. Pillars and tools of Lean Manufacturing.
Note Source: Dennis, P. (2009). *Produção lean simplificada*. Bookman Editora.

Dennis (2009) represents the activities and pillars of Lean Manufacturing in the form of a house, according to Figure 1. The basis is stability and standardization and its pillars are the concepts of Just in time and *Jidoka*, translated from Japanese as automation. Above all, on the roof, the focus is on the customer and in each part of the house, the corresponding tools.

2.2 Layout

For Slack et al. (2018), layout consists of the concern of the physical location of the transformation resources, "to define layout is to decide where to place all the installations, machines, equipment and production personnel". Peinado and Graeml (2007) state that the need to make decisions about layouts is justified by the need to expand production capacity, the high operational cost of inadequate layouts, the introduction of a new product line, the improvement of the work environment, the economy of movements and the need to change as changes occur.

The elaboration of a layout is influenced by several factors: location of the factory, access roads, available spaces, type of building, possibility of expansion, raw material, product, production process, equipment, movement of materials and products, storage, control and maintenance, labor and environment (Ledis, 2012).

According to Silva (2009), there are 10 types of layouts.

Key-word	Quantity of occurrences			Percentage
	Google Scholar	Web of Science	CAPES Portal	
Functional layout	60900	213	172	24,36%
Layout by product	101000	2323	266	41,17%
Positional layout	15700	95	12	6,28%
Cellular layout	34000	1301	81	14,06%
Modular layout	14500	826	15	6,10%
Mini-factories layout	198	3	0	0,08%
Holographic layout	2160	98	0	0,90%
Fractal layout	3600	121	2	1,48%
Reconfigurable layout	677	482	0	0,46%
Layout by virtual cells	12700	133	7	5,10%

Figure 2. Quantity of occurrences of layout types.

According to the Figure 2, it was found that 85.88% of the occurrences in three databases are limited to the four traditional layout types:

- Layout by product or in line – involves locating the transforming productive resources according to the best convenience of the resource that will be transformed (Slack et al., 2018).
- Functional layout or by process – similar processes or with similar needs are located together, that is, all resources of the same type and function remain grouped in the same area (Slack et al., 2018).
- Cellular layout – all the transforming resources necessary to meet the immediate processing needs of a given transformed resource are in the same location, that it, a cell (Slack et al., 2018).
- Positional or stationary layout – consists of moving equipment, machinery and people to and from the processing site when necessary, while the item being processed remains stationary (Slack et al., 2018).

3 Methodology

This topic was divided in order to describe the research classification, the method used to define the methodology to be used for elaborating the layout.

3.1 Research classification

This work can be classified as an applied research, qualitative, exploratory and bibliographic approach. It is an applied and exploratory research, as it aims to do a deep research about the main topic and generate knowledge for application in the preparation of the layout of the company's assembly line used as a case study (Raupp et al., 2006).

3.2 Application in the welding industry

The research of this study is classified as a case study which represents the most appropriate strategy when asking questions such as "how" and "why" (Yin, 2015). Three main sources of evidence were used, which were oral interviews with employees in the assembly sector, as well as the Production Planning and Control (PPC), Logistics, Production Support and Industrial Management department; company documents and databases; and observations made during visits to the company.

In order to evaluate the methodologies of layout elaboration and select the most relevant to be used in the welding industry in question, a relationship matrix adapted from Hofmeister (1995) was used and the Systematic Layout Planning (SLP) was selected, according to Töbe et al. (2020).

3.3 Systematic Layout Planning and Lean Manufacturing

The SLP methodology was developed by Muther & Wheeler (2000) and it is composed of a model of nine steps for identification, evaluation and visualization of the elements and areas involved in the planning of a layout (Alex et al., 2010 and Werner et al., 2018).

The application on the assembly line of the welding industry used the nine steps of the SLP methodology, plus three steps related to the principles of lean manufacturing, following the flowchart shown in Figure 3, where the added activities are highlighted with dashed lines.

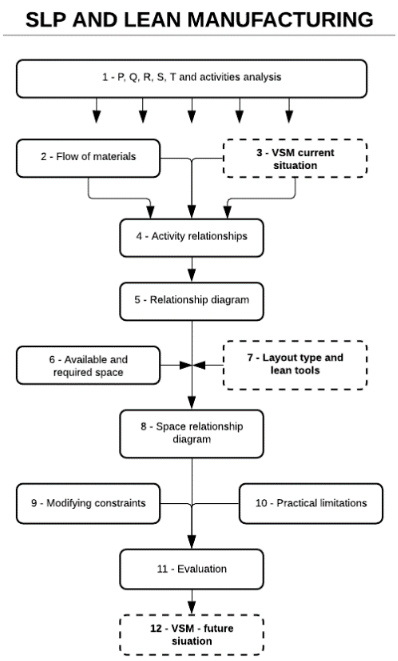

Figure 3. SLP and lean manufacturing.

The first step added was the elaboration of the Value Stream Mapping (VSM) for the current layout. The second step included was the definition of the layout type and tools of lean manufacturing which help in proposing the new layout for the assembly line. The third stage included was the elaboration of the VSM regarding the layout of the proposed situation.

4 Analysis

This topic describes the analysis done before proposing a new layout, which corresponds to the first seven steps of the SLP methodology.

4.1 P, Q, R, S, T and activities analysis

For this analysis, all the welding torches assembled in the industry were surveyed, as well as the demand of the last three years, ordering them by highest to lowest production.

After ordering the torches from highest to lowest demand, the first three standard torches were selected, that is, primary torches in the company's product mix. For these torches, volume of products per month (P), quantity of batch (Q) and setup, movement, and activity times (T) in minutes were the support equipment and route traveled were listed (see Table 1).

The MIG/MAG torch does not have a defined batch, as Production Orders (PO) are issued in specific quantities to meet the order point of this company's product line. It is worth mentioning that components used in the assembly of torches are considered as pre-assembly.

Table 1:

Prioritization of highest demand torches.

Product	Volume of product/month (piece)	Quantity of batch (piece)	Movement time (min)	Assembly time (min)
TIG torch 3,5M 13MM	84	31	1,50	5,00
TIG torch 3,5M	61	31	1,50	5,00
MIG/MAG torch 3M	23	0	2,00	5,00

The route (R) for all the three torches is the same: PO printing and booking – pre-assembly, materials gathering for pre-assembly (kanban), pre-assembly, storage of components finished on the kanban shelves, PO printing and booking – assembly, materials gathering for assembly (kanban), assembly and testing, packaging and placing the finished torches in specific area.

The support equipment for TIG torches are device for cutting cables, crimping device, screwdriver, continuity test device, flow meter, general tools and movement trolley. And the support equipment for MIG/MAG torches are device for cutting and striping liners, bending and fixing torch necks, cutting monocables, fixing plugs, crimping device, screwdriver, continuity test device, flow meter, general tools and movement trolley.

4.2 Flow of materials

Once the monthly volume and product route had been analyzed in the previous step, the grouping of products into families considered the two product lines - MIG/MAG and TIG line. The implementation of the kanban in the assembly line is in progress, in which the inputs are available in supermarkets, but not yet at workstations. In addition, the current layout has the 5S tool fully implemented.

Considering the route indicated in the previous step and detailing the flow of materials, for the assembly of MIG/MAG torches first the PPC department needs to print POs for the pre-assembly of components. The PO is issued by the Enterprise Resource Planning (ERP) system from the need for production. The company is in the implementation phase of the Overall Labor Effectiveness (OLE) project, which consists of providing tablets to operators so that the POs, drawings, and work instructions needed for the assemblies are displayed, eliminating the need for printing.

Afterward, it is responsibility of the PPC department to deliver the POs to employees so that they collect the necessary inputs and start the pre-assembly of the liner, monocable, plug and torch neck. Once finished, the liner and monocable are stored in the supports and the plug and the neck in the kanban supermarket.

The ERP issues the need to produce torches, the PPC department prints the POs again and delivers them to employees. To assemble the torches, it is necessary to collect the liners and monocables on the supports, in addition to the other components in the supermarket. After

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assembly, the torches are tested in the workstation itself, taken to another bench for packaging and, finally, moved to the finished product area.

The flow of materials for the assembly of TIG torches is similar to MIG/MAG, except for the fact that there is only one pre-assembly, of power cables, which, after assembled, are stored in supports.

4.3 VSM – current situation

In this step added to the methodology, the VSM of the current situation was elaborated with the objective of using it as a comparison parameter for the proposed layout (see Figures 5 and 6). For the development of the VSM, the second was used as a unit of measurement and the legend represented by Figure 4 for the symbols.

Symbol	Legend
	Local
	Flow of manual information
	Flow of automatic information
	Pushed production
	Pulled production
	Logistic process
	Check (file)
	Employees
	Information box
	Process box
	Kaizen application
	Air transport
	Land transport

Figure 4. VSM legend.

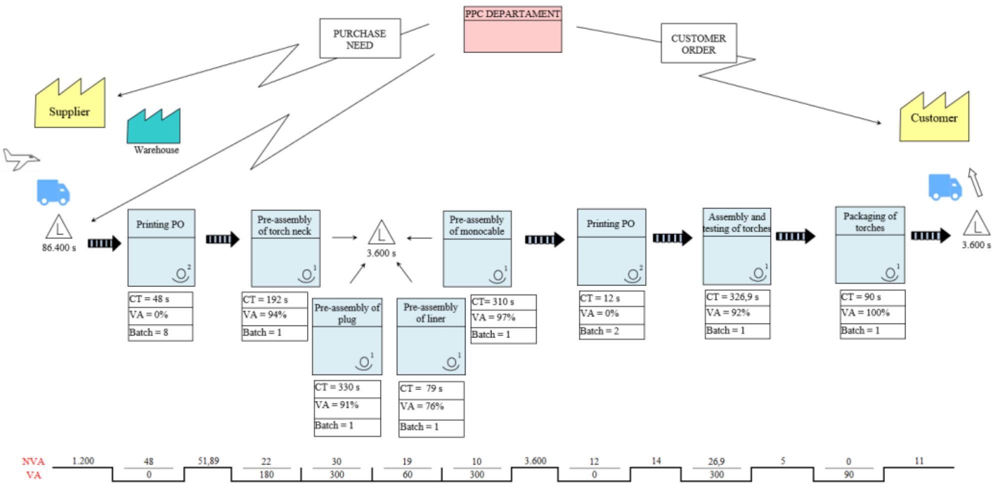

Figure 5. Value Stream Mapping of MIG/MAG torches – current situation.

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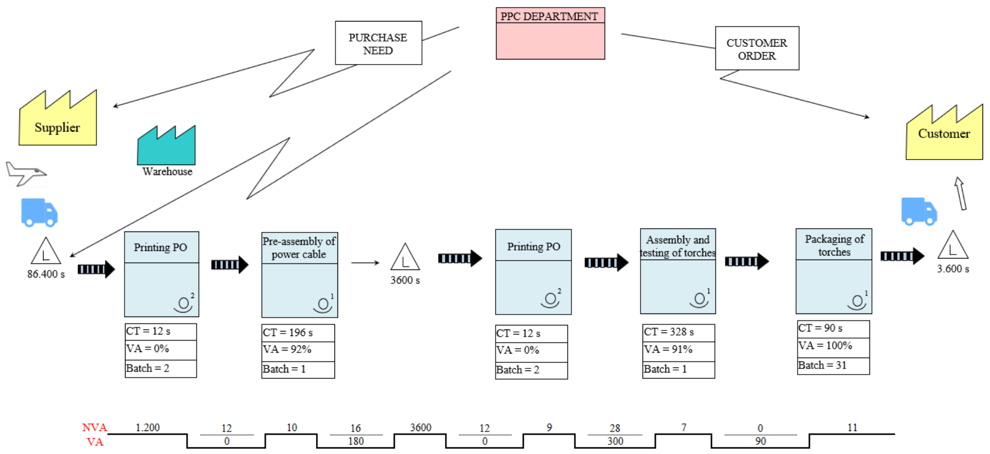

Figure 6. Value Stream Mapping of TIG torches – current situation.

Cycle time (CT), value-adding time (VA), non-value-adding time (NVA), lead time and the percentage of value-added were used as parameters of analysis (Rother & Shook, 2009). Both value-adding time and non-value-adding time were resulted from time studies using chrono analysis as methodology (Barnes, 1977). The results of the VSM of the current situation for the MIG/MAG and TIG torch lines are shown in Table 2.

Table 2:

VSM results of current situation.

Parameter	MIG/MAG	TIG
Cycle time (s)	1.397,9	638,0
Value-adding time (s)	1.230,0	570,0
Non-value-adding time (s)	5.049,8	4.905,0
Lead time (s)	6.279,8	5.475,0
Value-adding (%)	24%	12%

4.4 Activity relationships

For the diagram of MIG/MAG torch assembly relationships, four proximity reasons were used: reducing travel distances, independent processes, no possibility of layout changing and grouping pre-assembly process. The number three reason, "no possibility of layout changing", applies only to the relationships between the "Printing PO" and the others, since there will be no change in positioning in the PPC department office. For the A classifications, priority was given to directly related activities, such as the collection of liners and monocables for torch assembly, since these components are used in torches.

For the diagram of TIG torch assembly relationships, since there is only one pre-assembly activity, the power cable, the reason "group pre-assembly process". The classification of proximity used the same criteria as for MIG/MAG torches.

4.5 Relationship diagram

Based on the activity relationships, the analysis was performed using the relationship diagram to position the equipment and workstations in terms of proximity classification. The main objective of this diagram is to assist in redesigning the layout, since through it there is the visual positioning according to the classification performed in the previous step.

The relationship diagram must be made listing, initially, the activities whose relation was classified in A (Muther & Wheeler, 2000). Then, the relations with classification E must be added, including any new activity involved and redistributing those classified in A in order to arrange them respecting the relationships. In the same way, it is performed with the relations I, O and X, and those classified in U, unimportant, are not represented in the relationship diagram.

For the MIG/MAG torch relationship diagram, the torch-related activities, with the pre-assembly components already available, are those that have the highest priority in terms of proximity, being classified in A, and are related for the reason of reducing travel distances. The activities whose relationships were classified in E and I are related to the reason of grouping pre-assembly processes and/or reducing travel distances. And the activities whose relations were O received this classification because they are independent processes.

The TIG torch relationship diagram follows the same reasoning as MIG/MAG torches.

4.6 Available and required space

This step aims to measure the space available and necessary for the equipment, workstations and auxiliary resources, in order to make the proximity indicated through the relationship diagram. The plant drawing of the assembly line was used for this analysis and the available space was considered sufficient for the layout changes.

4.7 Layout type and lean tools

This step was added to the SLP methodology so that the layout planning would be carried out using the principles of lean manufacturing as the main driver.

For the definition of the layout type to be considered in the layout redesign of the assembly line, the type of manufacturing process of the welding industry was defined as a batch process, which consists of “a wider range of volume levels and variety than other types of processes” (Slack et al., 2018). In other words, whenever there is a need to produce a product model, more than one unit is produced, with the batch being two or three products. Thus, the assembly operations are repeated whereas that batch is being assembled.

The manufacturing process of the welding industry used as a case study fits into the batch type process since the components and torches are assembled in batches to meet the order point of their respective part numbers. This parameter is based on the demand of the item, either for consumption in assembly and / or on sale.

The types of layout related to this type of process are the process or cellular layout (Slack et al., 2018). Since the objective of this paper was to elaborate the layout of the assembly line of a welding industry using the principles of lean manufacturing as the main driver and considering Figure 7 and Table 3, the cellular layout is the most suitable.

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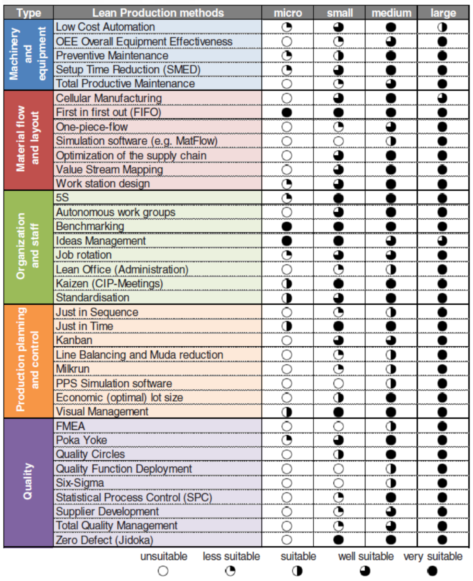

Figure 7. Lean manufacturing tools related to a company size.

Note Source: Matt, D. T., & Rauch, E. (2013). *Implementation of lean production in small sized enterprises.* Procedia Cirp, 12, 420-425.

Table 3:

Analysis of layout types considering lean manufacturing.

Layout types / Criteria	By process	By product	Positional	Cellular
Continuous flow	Low	High	Low	High
Inventory	High	Low	High	Low
Visual management	Low	High	High	High
Quality	Low	High	High	High
Mix and volume flexibility	High	Low	High	Low
Multifunctional workforce	Low	Low	Low	High
Programming complexity	High	Low	Low	Low
Motion	High	Low	High	Low

Note Source: Silva, A. L. D. (2009). *Desenvolvimento de um modelo de análise e projeto de layout industrial, em ambientes de alta variedade de peças, orientado para a Produção Enxuta* (Doctoral dissertation, Universidade de São Paulo).

It is worth mentioning that the current layout already has pre-assembly and assembly cells. In addition to this factor, the sector of assembly of the headquarter of the welding industry, located in Germany, is considered as benchmarking and also presents a cellular layout.

For the definition of the lean tools to be used in the layout of the assembly line, Figure 4 must be considered, which relates the type of area to be improved with lean tools and the size of the company. The welding industry is classified as medium size (BNDES, 2020), since it has annual gross operating revenue greater than € 714.902,74 and less than or equal to € 44.681.421,00.

As a medium-sized company, the layout to be improved and according to Figure 7, below follows Table 4 with the considerations about the lean tools to be considered or not in the proposal of layout of the assembly line.

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Table 4:

Lean tools considered in the proposed layout.

Lean tool	Classification	Applicable?	Reason
Cellular manufacturing	Very suitable	Yes	In accordance with the definition of the layout type described above.
First in first out (FIFO)	Very suitable	Yes	Considering the implementation of kanban in the assembly line and since this tool is already applied in the company's warehouse.
Optimization in the supply chain	Very suitable	Yes	Considering the implementation of kanban in the assembly line, optimizing the replacement of components.
Value Stream Mapping	Very suitable	Yes	Included as a step in the methodology of layout planning as a tool for analysis and comparison of results.
Workstation design	Very suitable	Yes	The current workstations consider the ergonomics, work safety and quality of life of users and it will not be changed.
One-piece-flow	Well suitable	No	The batch size of the POs is directly related to the fulfillment of the order point of the components and torches assembled in the welding industry.
Simulation	Suitable	No	The use of simulation software was not prioritized, as the company already uses VSM in its internal projects, being a tool well accepted by other subsidiaries in the welding industry.

Therefore, all lean tools indicated as very suitable will be considered and applied to the new layout of the welding industry assembly line used as a case study for this paper.

5 Results

This topic describes the results after the analysis done, which corresponds to the last five steps of the SLP methodology.

5.1 Space relationship diagram – initial proposed layout

The main alteration in the proposed layout is the division of the second pavement into pre-assembly and assembly cells instead of maintaining the product line division. Visually and having as reference the access ladder to the second floor, the left side will include the pre-assemblies of components and the right side the assemblies of torches and robot cables. The monocable cell, which is component pre-assembly, will not be changed, since it is strategically located in the middle and in front of the PPC department office and is related to the assembly of MIG/MAG torches and robot cables.

In this way, the amount of transport is reduced and becomes visually linear, since production starts on the left side from the pre-assembly of components, there is storage in supermarkets and supports in the middle of the second floor so that there are the assembly torches on the right side. According to the cellular layout, there will be two macrocells, one of which is pre-assembly and assembly, and within each of them, the cells listed according to Table 5.

Table 5:

Macrocells of pre-assemblies and assemblies.

Microcell of components pre-assembly	Microcell of torches and robot assemblies
Power cable cell	MIG/MAG torch cell (gas cooled)
Toch neck cell	MIG/MAG torch cell (water cooled)
Plug cell	TIG torch cell
Liner cell	Robot cable cell
Wire guide tube and cable assembly cell	Packaging bench
Brazing cell	Kanban supermarket
Stamping cell	Liner, monocable and power cable support

There will not be inclusion of new tables and workstations or any other equipment. The only inclusion will be new supports for storing liners of 3, 4 and 5 meters, in which they will be fixed to the wall next to the area of finished products. As there is a need to allocate specific lengths of liners and considering the presence of at least four operators with medium to low height, a lifting device will be contemplated for leveling the height and feasibility of collecting liners for the assembly of torches.

Positioning shifts considered the available space. The 5S tool, already implemented in the current layout, will be considered and maintained in the layout proposal.

5.2 Modifying constraints

This step is considered one of the practical points of the application and consists in interviewing the layout operators and users and collecting their needs. In this way, "there is the added advantage of making them feel that they have a personal part in a decision that affects themselves and their jobs" (Muther & Wheeler, 2000).

Therefore, the employees were interviewed, and the layout proposal was presented to them. Only one change consideration was reported in relation to the torch neck cell, which was initially in front of the power cable cell.

According to the operator, in view of the electrical point and the compressed air point, the torch neck cell should be located next to the power cable cell. So, in order to consider this suggestion, the power cable cell was moved about 3.00 meters to the right and, since it was already 2.10 m away from the stairs, it becomes viable the positioning of the torch neck cell next to it.

5.3 Practical limitations

Since there was no inclusion of new benches, workstations or any other equipment, the practical limitations considered were the electrical point and compressed air point, so that the positioning of cells and equipment respected the perimeter of coverage of these resources.

5.4 Evaluation

In this way and according to the feasibility of changes within the schedule of this project, the proposed layout was implemented. The improvement suggested by the layout users was considered in order to align their needs. It was possible to calculate the benefits in time and cost savings, which are described in the next topic.

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5.5 VSM – after layout changed

Equally to the third stage, this was added to the methodology so that the VSM of the situation after layout changed could present the results according to the new layout and was used as a comparison parameter to visualize the benefits in relation to the current situation. For the development of the VSM, the second was also used as a unit of measurement and Table III as a legend for the symbols.

For both VSM of MIG/MAG and TIG torches (see Figures 8 and 9), the conclusion of the kanban and OLE projects was considered, related to the availability of pre-assembled and assembled components in the workstations themselves and visualization of PO, drawings and work instructions via tablets with software integrated with the company's ERP system. Thus, for both situations after layout changed, the non-value-adding time of activities are reduced due to the elimination of the need for operators to collect inputs in supermarkets and, also, to the new layout.

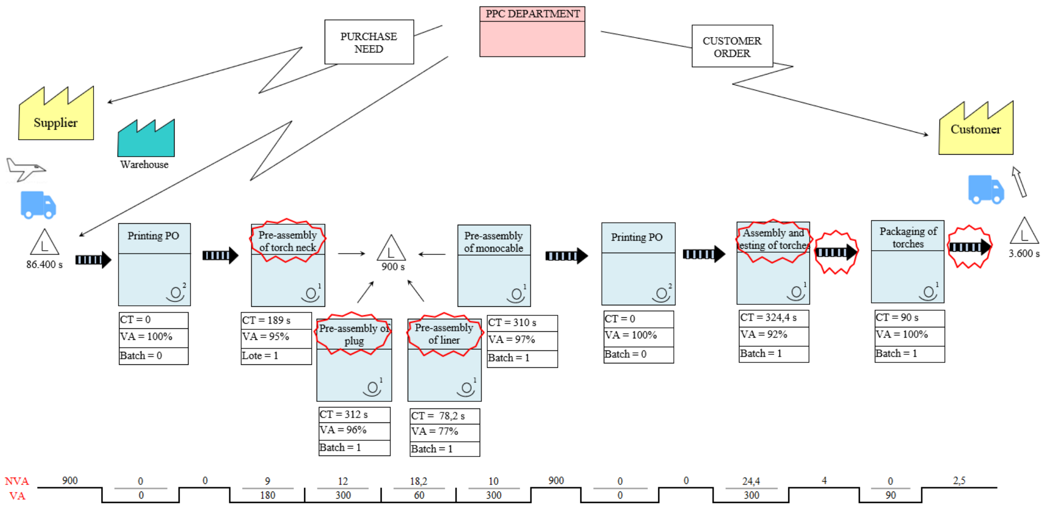

Figure 8. Value Stream Mapping of MIG/MAG torches – situation after layout changed.

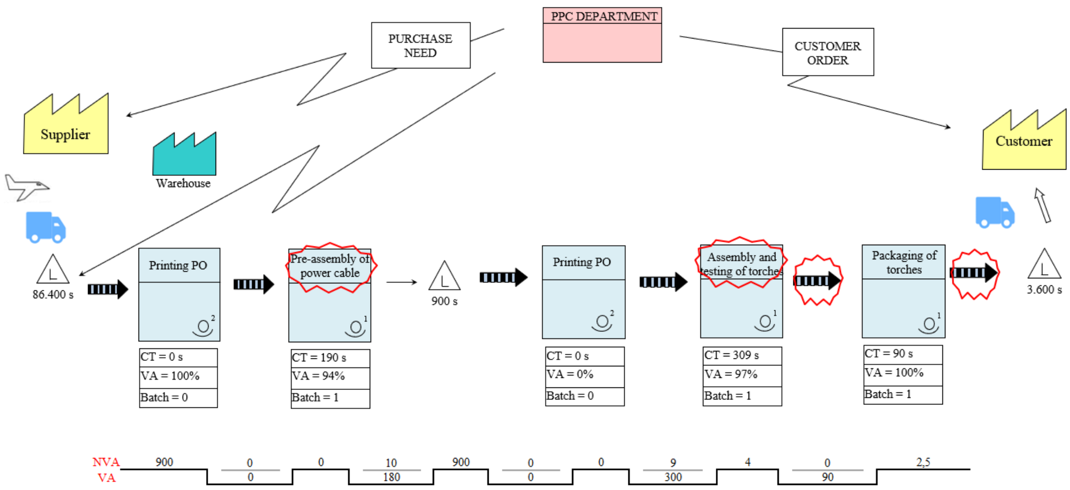

Figure 9. Value Stream Mapping of TIG torches – situation after layout changed.

For the analysis of results, the same parameters of analysis of the VSM of the current situation were used. Table VIII and XI show the results of the VSM of the situation after layout changed with the proposed layout for the MIG/MAG and TIG torch lines, respectively.

Table 6:

VSM results of MIG/MAG torches – situation after layout changed.

Parameter	Current	After layout changed	Variation
Cycle time (s)	1.397,9	1.303,6	⬇ 7%
Value-adding time (s)	1.230,0	1.230,0	0%
Non-value-adding time (s)	5.049,8	1.880,1	⬇ 63%
Lead time (s)	6.279,8	3.110,1	⬇ 50%
Value-adding (%)	24%	65%	⬆ 41%

Table 7:

VSM results of TIG torches – situation after layout changed.

Parameter	Current	After layout changed	Variation
Cycle time (s)	638,0	589,0	⬇ 8%
Value-adding time (s)	570,0	570,0	0%
Non-value-adding time (s)	4.905,0	1.825,5	⬇ 63%
Lead time (s)	5.475,0	2.395,5	⬇ 56%
Value-adding (%)	12%	31%	⬆ 19%

The cycle time will be reduced as employees will not need to collect components in supermarkets since they will be available at their workstations, in addition to the fact that the layout will provide a shorter travel distance between the cells and the supermarket for disposal of finished components. The value-adding time will not change, as assembly times were not considered as the focus of this paper. The non-value-adding time will be reduced due to the implementation of the OLE project, kanban and the reduction of distances with the new layout. In turn, the lead time will also have a reduction, accommodating reductions in cycle time and non-value-adding time and, consequently, the percentage of value-adding will increase for both torch lines.

To identify the reduction in movement time due to the layout proposed, only activities and movements emphasized with the kaizen symbol were considered. For the movements after the assembly, testing and packaging activities of MIG/MAG and TIG torches, the time reductions were considered in their entirety. Time reductions related to PO printing activities were not considered as they were caused exclusively by the OLE project. For the reduced times in the other activities emphasized with kaizen symbol, only half the time decrease was considered, since they are also related to the implementation of the kanban project.

Therefore, according to Table 8, there will be a decrease in movement time by 25 seconds for the assembly of a MIG/MAG torch unit and 18 seconds for a TIG torch unit.

Table 8:

Total benefit.

Parameter	MIG/MAG	TIG
Reduction in movement (s)	25	18
Annual demand – sample (piece)	358	2.000
Cost saving/year – sample (€)	€ 551,92	€ 2.220,00
Annual demand – gas cooled torches (piece)	4.805	3.728
Cost saving/year – gas cooled torches (€)	€ 7.407,71	€ 4.138,08
Annual demand – gas and water-cooled torches (piece)	5.781	3.745
Cost saving/year – gas and water-cooled torches (€)	€ 8.912,38	€ 4.156,95
Total cost saving in movement (€)	€ 13.069,33	
Labor cost (€)	€ 932,40	
Infrastructure cost (€)	€ 70,00	
Implementation total cost (€)	€ 1.002,40	
Annual benefit (€)	€ 12,066,93	

The cost saving study was carried out in three stages and considered estimated values. First, considering only the annual demand of the selected torches through the P, Q, R, S, T and activities analysis. The second considering only gas cooled, since the selected torches are into this category. The third considered the annual demand for all torches done in the assembly line, both gas and water cooled. For the calculation of the cost saving, the demand for the reduced time in seconds was multiplied, transforming the unit of measurement into hour and, finally, multiplying by the company's man-hour value. Therefore, there is a total cost saving of € 13,039.33 due to the layout proposed by this paper.

Regarding the cost of implementing the layout, 4 hours are considered in addition to the three liner supports for 3, 4 and 5 meters, which were purchased and fixed on a wall near the MIG/MAG torch cell, totaling € 1,002.40. Consequently, the annual benefit of implementing the proposed layout is € 12,066.93.

6 Conclusion

This paper aimed to redesign the layout of the assembly line of a welding industry using lean manufacturing as the main driver.

According to the method of evaluation and selection of methodologies for the layout planning, the Systematic Layout Planning was defined as the model to be used in the redesign of the layout of the welding industry according to its specificities.

VSM was selected as the tool for measuring and comparing results. Based on the VSM of the situation after layout changed, it was identified that the new layout will offer a reduction of 25 seconds for the assembly of a MIG/MAG torch unit and 18 seconds for a TIG torch unit.

It is concluded that the implementation of the layout proposed in its entirety will bring to the company in the first year a reduction of € 12,066.93 in costs invested in movement times. In the following years, this avoided cost will be € 13,039.33, since with the changed layout, there will be no implementation cost. This cost saving refers to current demand database, so it is possible to increase this annual benefit due to the growth in demand.

The implementation of the layout proposed by this paper is relevant, since if the layout remains in current conditions will continue to decrease the productivity indicators of the factory by 10% and add 28% in production times, both due to the movement times.

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