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A methodological approach for kaizen events in assembly lines

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Abstract: This paper proposes a methodology for the planning and execution of a *kaizen* event in a manufacturing assembly line. The method consists in 3 steps each one divided into 2 others: Planning (Project + data collection); Execution (participants training and *in loco* analysis) and results (benefits and future propositions). The methodology was tested in 2015 during a *kaizen* event conducted on a manufacturing lighting fixtures firm located in the industrial district of Milwaukee, WI, and applied to an assembly line whose problem consisted in excessive lead times and high mismatch times between workstations. The results show a successful application of this methodology. The *kaizen* event promoted a lead time improvement of 17.8% and a reduction of 91.13% mismatch time between workstations, besides improvements regarding human aspects. In this way, we provide evidence of a powerful tool that can be used to help firms to get their own human resources to solve problems and improve the work environment.

Keywords: Lean Production; Process Improvement; *Kaizen* Events; Work Design; Assembly Companies

1. Introduction

In a world that requires companies to make ever-faster changes and adaptations that easily stabilize in their systems, fast development solutions are always sought after. Literature point out to the use of "traditional" tools such as process flowcharts, cause-and-effect diagrams, Pareto charts and lean production tools through quality circles and continuous improvement teams to identify problems and implement low-cost improvements (Aken *et al*., 2010). In this way, k*aizen* events are seen as an alternative for companies to achieve these goals. Besides, this action has also some advantages when compared to traditional continuous process improvement teams once it is planned on a short time-frame with high implementation focus (Aken *et al*., 2010; Cohen and Bailey, 1997).

Kaizen events have been widely reported to produce positive changes in business results and human resource outcomes, providing evidence that these areas impact each other on the pursuit of continuous improvement (Glover *et al.,* 2011). In addition, there is a strong evidence of the benefits promoted from this initiative. Since *kaizen* events are generally associated with systems guided by principles of Lean manufacturing, literature often reports technical improvements to waste reduction, lead time and balancing of work stations, work-in-process inventory, productivity and throughput and line efficiency (Aken *et al*., 2010; Junker, 2010). Social system improvements, in turn, generally comprehend developments in knowledge and skills, once *kaizen* events serve as a training mechanism (Yang, 2016). Moreover, *kaizen* events may also help firms to motivate and increase employee's commitment, once appreciation and enthusiasm are considered a formal objective and a benefit of this initiative (Melnyk *et al*., 1998; Farris *et al*., 2008).

This type of events has been used in several companies and in various departments within these companies, from advanced manufacturing industry to health institutions (Farris *et al*., 2008; Dickson *et al.*, 2009). Within the companies the events has been carried out in a large variety of areas, such as manufacturing, engineering, sales and product development. In this way, since the assembly line is a widely-used type of production system (Rekiek *et al*., 2002), k*aizen* events are largely applied on the design and problem solving situations, which are usually related to: balancing and dimensioning of workstations (assignment of operations to workstations), dimensioning storage areas, dimensioning transportation systems, layout, etc. (Rekiek *et al*., 2002).

The concepts presented concerning *kaizen* events and its objectives, well as the benefits from this application indicate the importance of this action to support and maintain the overall efficiency of a production system. However, as stated by the literature, there is a lack of studies guiding companies about *how a kaizen event should be conducted* (Aken *et al*., 2010; Glover *et al*., 2011; Farris *et al*., 2008), once most part of works regarding this topic are dedicated to report results of *Kaizen* events applied to specific environments. In addition, studies relate to configuration of assembly lines are usually focused on the use of simulation, heuristics and other computational methods that require a certain expertise and sometimes disregard human aspects. Thus, this study intends to contribute to the current literature, not only by presenting an example of a k*aizen* event implementation, but also with the proposition of a methodology to promote workforce integration on the pursuit of performance improvements and problem solving in assembly lines. In this way, this paper reports a successful application of a *kaizen* event that took place in 2015 in a manufacturing lighting fixtures firm located in the industrial district of Milwaukee, WI. The purpose of this initiative was to identify and promote short-term improvements for an assembly line whose main problems consisted in excessive lead times and high mismatch times between workstations. The methodology was developed and tested during the *kaizen* event and document after the follow up actions. The outcomes, which were far better from excepted, show a successful application of the kaizen event conducted.

The reminders of this paper are organized as follows. Section 2 presents a background on k*aizen* events and the importance of having the right design for assembly lines, while section 3 introduces the methodology and a model to help guiding the event. Section 4 brings the case study. Section 5 is dedicated to discussions, which also concerns lessons learned and, finally, section 6 addresses the conclusions of this work.

2. Theoretical background

Kaizen events, also known as "rapid improvement events", "accelerated improvement workshops", "*gemba kaizen*", and "*kaizen blitz*" can be defined as an extremely focused and structured improvement project, which uses a cross-functional and semi-autonomous teams mentored by a leader and targeted to a specific work area to promote improvements and solve problems with specific goals (Aken *et al*., 2010; Glover *et al*., 2011; Farris *et al*., 2008). During *kaizen* events participants are able to identify problems and apply solutions based on low cost implementation tools and in a short period of time – usually 3 to 5 days (Melnyk *et* *al*., 1998; Farris *et al*., 2008). Thus, *kaizen* events have become popular as a quick way for companies to introduce improvements (Farris *et al*., 2008), once the *kaizen* philosophy itself may turn a profitless company into a profitable one without an enormous investment in equipment and technologies (Lyu, 1996).

Most *kaizen* events are conducted according to a sequence of typical steps: (*i*) team preparation, (*ii*) documentation of current state, (*iii*) identification of opportunities for improvements, (*iv*) improvement selection (often implementation), (*v*) results presentation and (*vi*) documentation of an action list for follow-up activities and the methodology applied itself (Aken *et al*., 2010; Melnyk *et al*., 1998). It is important to highlight that the extension of a *kaizen* event goes beyond obtaining results and one of the most important activities is related to the maintenance of the achieved benefits. The quantity of people assigned to participate of the event may vary from 6 up to 15 people (Laraia *et al*., 1998) and it is essential the presence of a facilitator not only to conduct the event itself but mostly to work before and after the event is done (Aken *et al*., 2010).

The benefits of the relative speed in which a kaizen event is conducted and its generic implementation facilitate the suitableness of this action in a wide range of quality projects. Literature provides evidence of successful application of *kaizen* events in different sectors which vary from its original conception on the automobile industry (Gloover *et al*., 2015). Other examples of sectors in which *kaizen* events have been implemented are presented at education (Alexander and Williams, 2005), sales (Farris *et al*., 2015) and healthcare (Knechtges and Decker, 2014; Rosenkrantz *et al*., 2015). Among these diverse fields in which *kaizen* events may be successfully applied, literature broadly relates this strategy to manufacturing firms in which everyone, from factory floor to management are found together in a totally universal and integrated effort with the assembly line (Venkataiah, and Sagi, 2012). Benefits from the application of continuous improvement events move firms towards upgrades on their technical system, supporting specific problem solving situations while considering organizational learning and workforce integration simultaneously (Aken *et al*., 2010). There are distinct kinds of situations that an assembly line may face which require certain changes to be made. They can be classified in different ways and can also be solved by different approaches. Some of them are external to the company, as an example improvement in activities involving suppliers and consumers, which may also be associated to line capacity, while others are more internally related such as addition of a new products to the line

(Venkataiah, and Sagi, 2012), unbalancing of workloads (Salveson, 1955; Kriengkorakot and Pianthong, 2007; Raj *et al*., 2016) and work conditions (risk of injury among workers).

In assembly lines, one of the most common issues, however, regards line balancing. The Assembly Line Balancing Problem (ALBP) is a classic problem from literature, firstly approached by Salveson (1955) in the article *The Assembly Line Balancing Problem*. The problem focuses on assigning the set of elementary tasks necessary to assemble or disassemble a product in an ordered sequence of stations such that the precedence relations among the tasks are satisfied consistently and efficiently and some performance measures are optimized (Salveson, 1955; Kriengkorakot and Pianthong, 2007). Since then, a growing literature has been dedicated to discuss how to manage this problem and most of them rely in computation methods to simulate scenarios. Only a few studies use other methods, considering a less mathematical approach, such as workers training (Hermawati *et al*., 2015), Ergonomics (Bautista *et al*., 2015) and even Lean (Nguyen and Do, 2016; Lam *et al*., 2016).

For assembly companies, this initiative of using *kaizen* events, which is a Lean based technique can be useful to generate advancements and solve daily manufacturing problems with a quick response (Ortiz, 2006a; Ortiz, 2006b). Moreover, firms that apply Lean principles to their systems are usually working against wastes, which can be characterized in eight types: (*i*) Transport, (*ii*) Inventory, (*iii*) Motion, (*iv*) Waiting, (*v*) Over production, (*vi*) Over processing, (*vii*) Defects and (*viii*) Skills (Liker, 2004; Womack and Jones, 2010) and should be eliminated (Liker, 2004; Womack and Jones, 2010; Lam *et al*., 2016). In the case of assembly lines, the design of an efficient system is one of the most critical points (Rekiek *et al*., 2002), once it can greatly contribute to reduce these wastes and, therefore, improve performance indicators, enhance customer value and promote high levels of competitiveness (Rekiek *et al*., 2002; Chryssolouris, 2006). Thus, in order to have an assembly line working with the right quantity of workers, resources and cycle time, it must be taken into account that the first step is to carry out a study regarding the understanding of its processes and the identification of its needs, and which tools can be deployed to achieve the ultimate goal: having a balanced and right-sided line (Sundar *et al*., 2014; Battaïa *et al*., 2015; Nguyen and Do, 2016).

3. *Kaizen* event for assembly lines (KEAL) proposal

This section is dedicated to present the methodology. Then, Figure 1 illustrates a model proposed to be implemented in an assembly line. Two particular aspects of this model are:

- ✓ The timeline of the entire action. The methodology considers three major phases: (*i*) Planning; (*ii*) Execution and (*iii*) Results, which are deployed as the event takes place; and
- ✓ The work is divided into detail levels. These levels should be considered as an action and planned according to the purpose of the event. The recommendation here is to only step up to the next level once the previous one is completed.

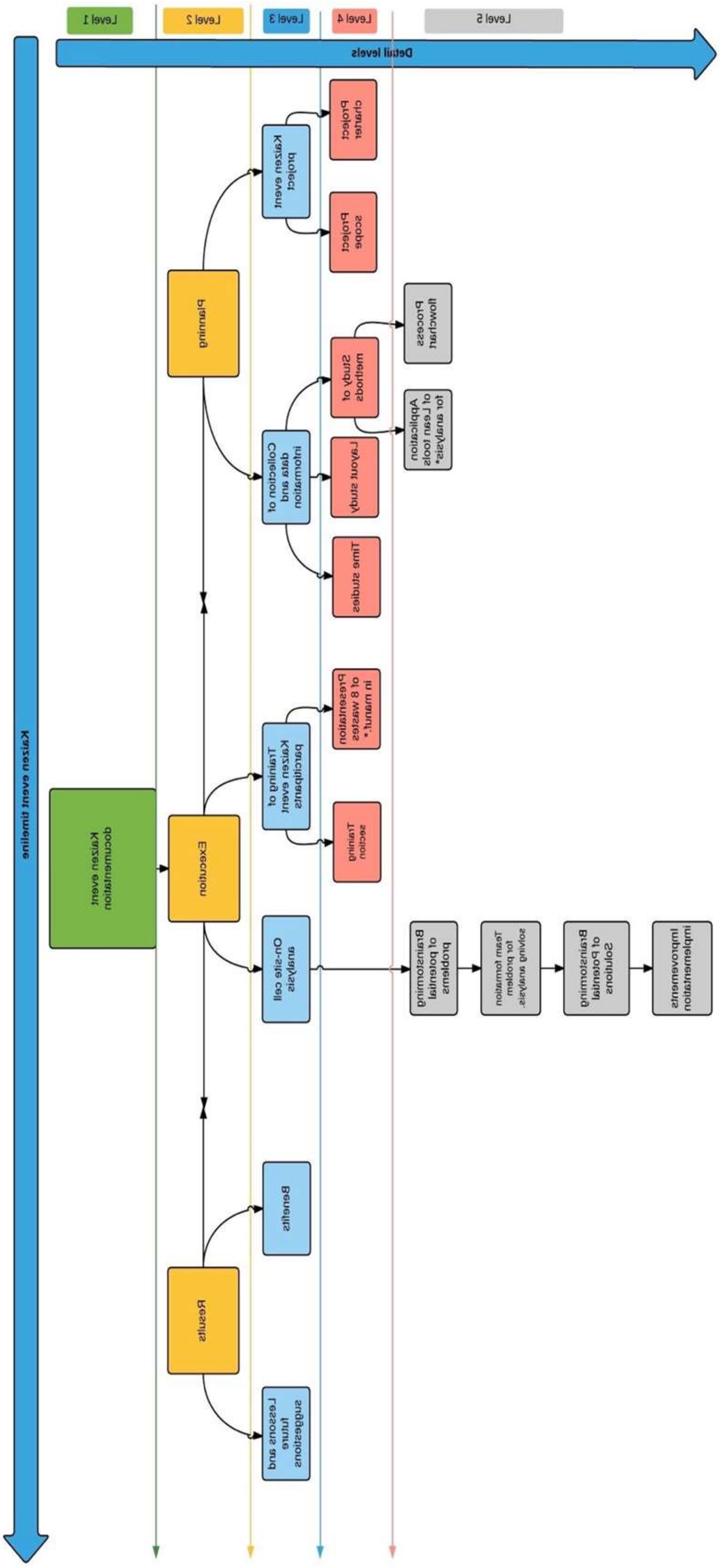

Figure 1: *Kaizen* event methodology – graphical model

It is important to note that the phases that take place before and after the *kaizen* event are equally important to make it a successful implementation. Most important steps take place before and after the event itself. For a good comprehension of what should be approached in each level, it is necessary to highlight what is mostly expected to be done and delivered in each one, beginning from the most detailed level:

- ✓ Level 5 – the boxes in both planning and execution phase are related to each other. For the planning phase, information is the most important deliverable. Therefore, the leader should watch and study the assembly line for a certain period of time and be responsible for describing the entire process flow. If necessary, there are certain tools that may help to visualize frequent movements around the line *e.g.* spaghetti diagrams. These results will give to participants the information for a better analysis and allow them to generate brainstorming and make considerations about what has been analyzed;

  Once problems and/or opportunities for improvements are identified, teams must be formed in order to generate different solutions. This level ends with a voting session of the best ideas and immediate implementation;
- ✓ Level 4 – this level is dedicated to formalize the action plan using both project charter and project scope and get the information necessary for scenario analysis which can be done by operations management tools, such as time and motion and layout study (Planning). The Execution phase is focused on training the *kaizen* event participants for problem solving and analysis. The purpose of this session is to empower the participants and provide knowledge for decision making during brainstorming that will take place at Level 5;
- ✓ Level 3 – the accomplishments at this level are more general and some points must be highlighted in each phase:
  a) Planning – a first deliverable of this phase regards the specifications of the event. In this level of the planning stage participants should be selected according to the purpose of the event. The quantity of people varies from 6 up to 15 (Laraia et al., 1999). Then, it is recommended to choose participants that: (*i*) work at the assembly line under study; (*ii*) work in other assembly lines; (*iii*) work in different areas such as: commercial and public relations (*iv*) engineers; (*v*) managers and even (*vi*) consultants from other companies. It is important to emphasize that this step is extremely important once the greatest

results can come from ideas generated by diverse people. Other specifications to be settled are: project goals; scheduling; supplies; resources and other requirements. Moreover, it is necessary to have the approval from managers and, sometimes, labor union in order to authorize participation, data collection and documentation;

b) Execution – since this stage comprehends activities that are executed during the 3-5-day period of the event itself, training and on site analysis are the most important points for accurate brainstorming and decision making. As explained in Level 4, the training section must be focused on the right tools for better conduction of the on-site analysis; and

c) Results – this phase consists in document benefits generated from the Execution phase and lessons learned for future *kaizen* event implementations.

- ✓ Levels 1 and 2 – these less detailed levels comprehend the general shape of the event and guidance regarding the sequence in which the steps should be taken. Finally, the first level of the event is dedicated to document benefits, plan for follow-up actions, lessons learned, as well as the methodology itself and its adjustments.

There are additional guidelines for the implementation of a successful *kaizen* event in assembly companies, however, a certain variability must be taken into account. In addition, we suggest to adapt this proposal according to several variables which are inherent to the company *e.g.*: company type, information policies, production strategy previously dominant, market conditions and many others. The next section brings an application of this methodology in an assembly company.

4. Case study

The company under study is specialized in the manufacturing and assembling of high strength lighting fixtures since 1944. The firm is located at the industrial district of Milwaukee, WI, and it is recognized as a reliable manufacturer for heavy industrial applications. In addition to this main range of product lines, another less expressive segment in which the firm is dedicated to is the manufacturing and assembly of welding kilns. The company accounts with four lines, responsible for 19 assembly lines, totaling 32 types of products in the segment of high-strength lighting equipment that serve three major market segments: ports, mining and maritime trade and wharf. According to the manufacturing department, all products are profitable and demanded in a regular basis. However, a specific line, responsible for assembling the products with the highest sales volume was not being capable to meet demand requirements and quality patterns and this was starting to become a major issue, especially noticeable with the loss of key customers. Then, the firm´s necessity to adjust itself to meet these requirements became urgent.

4.1. Phase 1 – Data collection from current scenario

The assembly line under study has three variations of the same product which differ from each other only by the addition of some extra components. As previously mentioned, the primary problem that motivated the company towards the *kaizen* event was the company's need to meet new demand expectations by increasing its capacity without addition in fixed resources. With a basic investigation, it was possible to identify that the cause of the problem was centered in the excessive amount of time necessary for the product to be assembled completely. Nevertheless, from the data collected, imbalance between the four workstations was also identified. Hence, to attack both problems, the first action took place before the event was conducted, in the data collection phase, objecting the understanding of the whole process and how it could be improved. In this way, the line was assisted for an approximate period of one week and the whole process was documented in a flowchart. The flowchart is shown in Figure 2 and it describes the whole process for all variations of products that are assembled in the line under study.

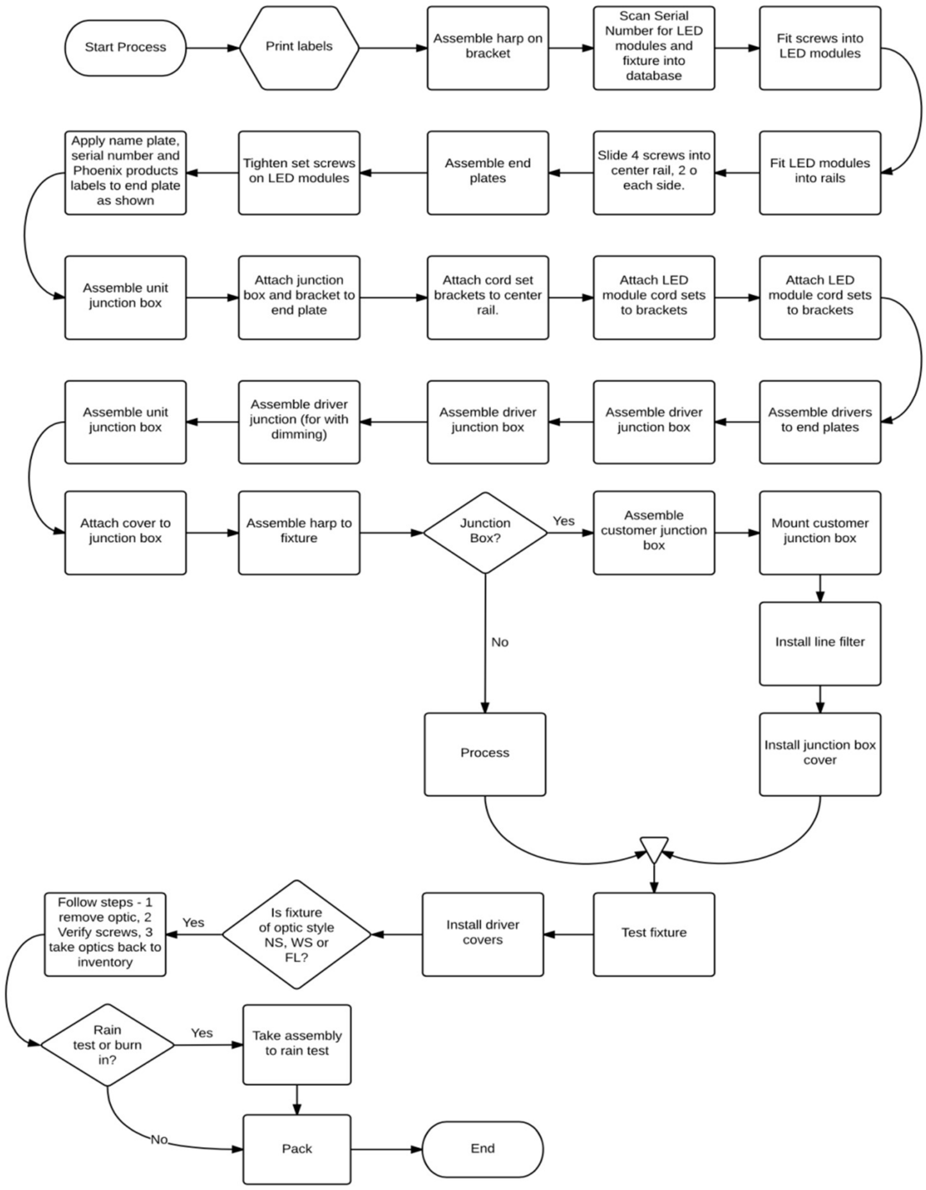

Figure 2: Process flowchart

The flowchart in Figure 2 was used during the event and it helps to identify which points to attack, based on the evaluation of unnecessary activities and how they can be easily improved. Another point of attention refers to the way in which activities were divided along the different stations, which comprehends the main cause for unbalancing assembly times. In addition to the evaluation of the process flow, a time study was conducted and, in summary, it presented a cycle time of 76.5 minutes and a difference of up to 19 minutes between workstation for the most complex product variation. The results highlighted the need to reconfigure the process and its division among the work stations.

Another way to approach this situation and get more information for a better understanding of additional causes was performing a motion study by means of a Spaghetti

Diagram. This tool promotes an overview of how workers move and communicate to each other. The main aspects that this tool aims to identify are: location of materials, equipment and trash cans, tools placement, necessity of tables of additional space (Yerian *et al*, 2015). Figures 3 and 4 present the two spaghetti diagrams designed based on videos recorded during two different shifts.

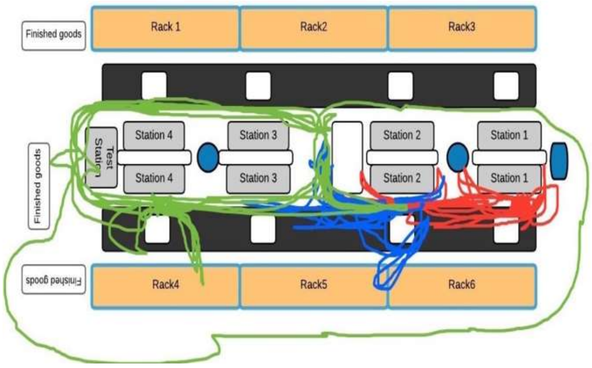

Figure 3: Spaghetti diagram 1 – first shift

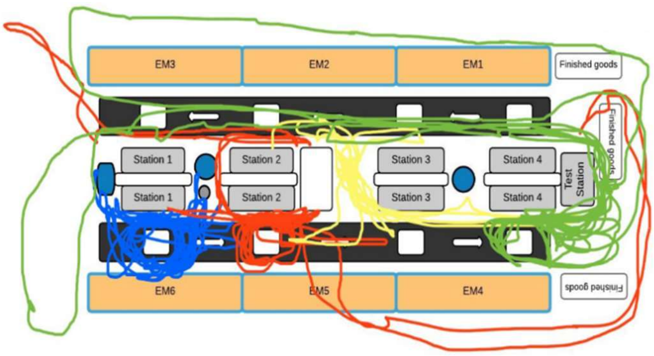

Figure 4: Spaghetti diagram 2 – second shift

4.2. Phase 2 – Execution of the kaizen event

At the execution stage, the selected participants were provided with all the information collected during the first phase of the *kaizen* event. The deliverables of the data collection phase were analyzed (flowchart, spaghetti diagrams, time study), as well as videos, photos and results of the training conducted through the application of the Lean game called *The single piece flow game*. The discussions and brainstorming promoted during this phase of the event highlighted new possible causes for problems. High degree of absenteeism, demotivation and lack of commitment to daily goals emerged as important topics that were not related to technical support. The participants that worked in the line claimed the absence of a production plan and a line leader to inform the exact quantity of product they were supposed to accomplish in the end of each shift. Sometimes, the manufacturing department did not provide the necessary information and did not assign the right amount of people to work on shifts. Moreover, topics that were not firstly considered, such as lack of skilled personnel and organization of materials and equipment also emerged as possible causes for the mentioned problems.

As it is possible to notice, the problems that were inhibiting the assembly line to reach its requirements were not only related to technical matters, but to human aspects related to quality and integration of personnel as well. During the execution phase, the participants were divided in teams to identify and prioritize route causes and propose solutions to them. In general, the root causes conveyed to unnecessary motion getting parts and tools, lack of space to assembly specific parts, inefficient layout planning and poor work conditions, lack of skilled workers due to recent hires and frequent job rotation. After all these root causes were listed, the possible solutions were also discussed. The teams came up with solutions on layout; line balancing; implementation of additional Lean tools; workforce motivation and even ergonomic improvements. These ideas were implemented after discussion and brainstorming sessions and voting. The line was modified and adjusted according to the suggestions generated during the k*aizen* event. Tests were conducted to verify new work routes and new cycle and balancing times. Figure 5 presents the new spaghetti diagram, which is an overview of how the physical arrangement was modified to simplify task execution. Moreover, it also illustrates worker's movement along the assembly line. Figure 6 shows a comparison of the assembly times before and after the event, respectively. From the comparison of these two scenarios (before and after the implementation of the *kaizen* event), we can assess the benefits generated by the improvements.

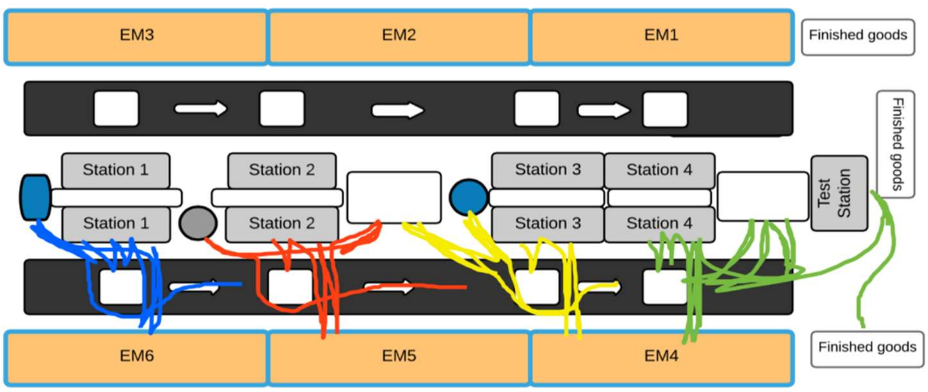

Figure 5: Spaghetti diagram 3 – Future State

The outcome of the new scenario in Figure 5 shows a simplified layout resulted from the brainstorming and application of the SSLP method (*Simplified Systematic Layout Planning*) with *kaizen* event participants. The major modifications that were made regard: (*i*) increasing the space between workstations; (*ii*) addition of a new table for assembly small parts; (*iii*) removal of a small trash can and (*iv*) addition of a big trash can; (*v*) installation of rubber floor along the line to improve work conditions. However, great part of the conflicts and unnecessary movements along the line were due to the lack of organization of parts and tools, *i.e.*, tools and parts were not available on the stations when workers needed them. Because of that, workers had to walk long distances pursuing these tools and materials. Then, other solutions that were implemented to target these problems were: (*i*) designing of shadow boards for tools, (*ii*) implementation of 5S and (*iii*) daily checklist for tools and equipment.

In addition to the actions dedicated to solving the identified problems, other changes more related to managerial aspects were suggested, such as:

- ✓ Training of new employees - Since employee turnover in this sector is considered to be high and the contracts are established for short periods, many workers end up not having sufficient familiarity with the product or the production when compared to others who already have more working time in that same assembly line. Thus, it was observed that all workers involved in the assembly line stopped the production to explain the process to new members of the assembly line. Therefore, in order to reduce not only the delay caused by these interruptions, but also the number of defects that the product presented, one solution proposed by participants at the *kaizen* event was to provide the newcomer with an individual training period before his regular integration into the assembly line; and
- ✓ Election of a line leader - The lack of someone to coordinate the pace of production, the organization of materials and to promote worker motivation was also a factor identified by the participants of the event as something that could be improved. Thus, the main effort to be undertaken in this area was to identify and choose someone who might be able to perform such functions. Initiatives such as implementation and coordination of 5S in the assembly line, product inspection between processes and control of work to meet daily demand are some examples of that. Then, it requires the presence of a line leader, someone who can report directly to the manufacturing management and work to ensure that production targets and worker´s needs are being accomplished.

These additional suggestions were implemented and in the end, the assembly line in which the event was applied obtained satisfactory outcomes, allowing the company to solve the problems previously targeted and promote a better work environment. Figure 6 shows cycle times before and after improvements. The reduction of 13.81 minutes represents and improvement of 17.8%. Line balancing was also improved. The difference on process times between workstation was reduced from 15 to 1.18 minutes, an improvement of 91.13%. Figure 7 brings a column graph with results from the time studies and the last assembly test performed after improvements were made illustrating this line balancing improvement. It is important to highlight that this result was promoted through the reconfiguration and division of tasks of the process flowchart by the participants themselves, instead of the computational techniques commonly reported the literature, as previously mentioned. Furthermore, the simulation was performed on the factory floor and not by the use of software, which disregard the perception of workers about changes and the new production pace.

Assembly	Stations				
	1	2	3	4	Total
0	24.5	26	15	11	76.5
1	21.06	21	17.22	15	74.28
2	18.34	11.12	25.22	15.30	69.98
3	16.18	15	15.46	16.05	62.69
Average	**18.5**	**15.7**	**19.3**	**15.5**	**69.0**

Figure 6: Cycle time comparison

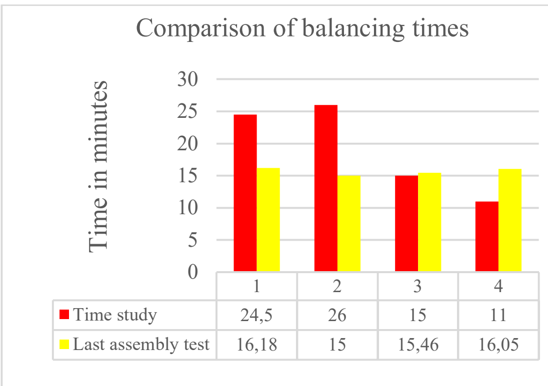

Figure 7: Line balancing comparison

5. Discussions

The results achieved through the application of the *kaizen* event in the case study revealed that the methodology was useful as both a design and an assessment tool, supporting previous literature of Aken *et al*. (2010), Glover *et al*. (2011) and Farris *et al*. (2008). In addition to that, the implementation of this initiative also greatly contributed to organizational learning, corroborating Aken *et al*. (2010). The three complementary phases promoted an accurate valuation of the problem and implementation of solutions. The planning phase was dedicated to data collection and event´s preparation (personnel selection and supplies). The execution phase comprehended the conduction of the event itself along three days. Finally, the results phase consisted on the assessment of the benefits generated by the *kaizen* event and the implementation of maintenance actions. The leadership exerted a strong influence in order to make goals clear so the scope could be defined accordingly during planning phase. The participants were trained and ideas were discussed and implemented after brainstorming sessions, which also helped integration and generated mutual understanding. However, lessons learned must be considered. These concerns are of the utmost importance and we recommend to take them into account for future implementations of this initiative. They essentially consist on:

- ✓ Goals must be clear and the leader have to make sure that every participant understands the problem once the information and data related to the current state is presented;
- ✓ Selection of right personnel for the event. It can be hard to find people that can contribute to idea generation, promote different and feasible solutions and that are also willing to participate of a *kaizen* event. Then, leadership should not force people to participate. There must be a mutual agreement and the personnel selected must know in advance that once they accept to participate they have to be committed with the purpose of the event;
- ✓ The planning phase is one of the most important aspects, since every step that will come next depend on a good planning. Thus, the *kaizen* event planner have to ensure that: schedule; materials for brainstorming and other activities; food; equipment (such as video cameras, television, computer, whiteboard) are settled and available for utilization;
- ✓ It is assumed that every person selected for participation can contribute in a specific way and everybody has equal voice. In this way, training session is important not only

to provide knowledge but to spread this mindset and make participants comfortable with themselves and with the leadership; and

- ✓ Results do not last forever. In this way, there should be a final review and a follow up approach, with a supportive management, in order to sustain improvements. The progress of the *kaizen* event, specially data collected and brainstorming sessions, should be documented, as well as the event itself. If necessary, these documents should be reviewed and additional meetings should be scheduled, even if the event is finished, in order to discuss improvements maintenance.

The case study presented provided sufficient evidences to support literature regarding both addressed topics – *kaizen* event and assembly lines. As mentioned previously, two of the most common issues in assembly lines are the line unbalancing problem and excessive assembling lead times and this work brings one more example of these two common problems faced by a lighting fixture assembly line. Literature also points out that a possible solution for these problems should rely on task assignment, which must be organized consistently and efficiently to promote a good line performance. Moreover, we decided to follow the literature in one more point, which is the adoption of a *kaizen* event implementation to promote improvements.

Finally, the initiative of adopting a *kaizen* event has proved to be successful and the methodology generated has proved to be efficient. However, we also found that there are certain aspects which can make a *kaizen* event difficult to be institutionalized. For instance, management in some departments can be hesitant to conduct *kaizen* events owing to perceived resource conflicts and the availability of personnel as well as data collection and disclosure. Furthermore, workers may be uncomfortable with some procedures taken in the data collection phase such as: process supervision, documentation, video and photographic recording of the line's daily activities. So in some cases, it may be necessary to have the approval of the line workers under study and, for some procedure, even union is required to provide approval so that necessary steps in data collection can be accomplished.

6. Conclusions

This paper presented a methodological alternative for implementation of *kaizen* events in assembly lines, evidenced by a practical experience in an assembly company. The method takes into account the existence of 3 major steps – Planning, Execution and Results – which are deployed into more detailed levels, accomplished by activities that take place along the event. The methodology was applied in an assembly line whose problems consisted in excessive lead times and excessive mismatch times between workstations.

Prior knowledge about the work environment as well as techniques related to method engineering were required to conduct brainstorming and promote accurate insights about work design. Thus, several tools were used for data collection, analysis of the current scenario and problem solving propositions. In summary, it can be said that the event led the company to achieve significant improvements, which can be attributed to two complementary pillars: a tangible and an intangible one. Tangible improvements point to the reduction of 13.81 minutes of the total assembly lead time, approximately 17.8% less when compared with the original scenario.

Added to this, it is also worth noting that the line balancing, achieved through analysis and redesign of the entire process by the participants of the *kaizen* event themselves, resulted in a time reduction between workstations from 15 minutes to 1.18 minutes, an improvement of about 91, 13%. Furthermore, as mentioned, intangible improvements were also achieved among which we can point: (*i*) the increase of motivation and commitment among employees; (*ii*) generation of a database and a methodology for future *kaizen* events and (*iii*) the consolidation of the continuous improvement culture based on the Lean strategy. Results of this application helps to support the intention of formalizing this initiative for future implementation, once improvements beyond technical aspects were obtained and the outcomes were far better from expected.

In conclusion, the methodology show itself to be suitable in a manufacturing environment, specifically in an assembly company. However, it is worth mentioning that this research was conducted in a single company with particular traits that hinder any generalization of the results in a global context. In order to overcome this limitation, it is suggested for future research to test this methodology in other situations. The same methodological format presented in this paper can be applied in different assembly companies and in different types of production processes as well, such as: continuous; with less or higher levels of customization; in project implementations, to mention a few. In addition, services and public sectors can also be targeted. Company policies for data collection and disclosure, technical tools for analysis, materials, people selection and availability and the period of time that the event happen are some particularities that should be considered.

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