

Improvement of the Production Process via Kaizen: Case Study of A Wiring Company*

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Abstract— Many business organizations have started incorporating methodologies of resource wastage minimization, concentration on added value tasks and permanent quality improvement through the use of kaizen philosophy. The concept behind the Kaizen philosophy relies on the distinction between value adding and non value adding activities, and then the focus on improving the productivity level of some problematic work areas with low value adding activities via a series of incremental steps. Following many investigations in the automotive sector, the productivity is proved to be compromised usually in response to newly implemented changes that bring various issues to the production process or the sequence of tasks in the production line. This paper tries to illustrate how Kaizen strategies were adopted in automotive sector, in wiring specifically, to overcome those issues with a concrete case study of a wiring company that knows recurring configuration changes in their product components in response to newly car models launches brought up by carmakers.

Keywords—*production improvement; Kaizen; wiring*

I. INTRODUCTION

In the last few years, automobiles' wiring and control distribution system for the transmission of electrical power and signals have improved in many important aspects. In order to support these developments, wire harnesses' characteristics and designs change depending on the vehicles model, its new functionalities and features. Consequently, wiring companies should re-adjust their production procedures regularly to meet the customers' new specifications.

Moreover, the newly implemented changes bring various issues to the production line concerned. The latter needs to be dealt with by putting in place a correct analysis before applying the adequate solutions and improvements.

This paper tries to illustrate the lean strategies adopted to overcome those issues with a case study of a wiring company from Morocco and shed the light more specifically on the implementation process, taking into consideration attitudes of employees.

Lean practices are well known across manufacturing and business organizations, and has been applied widely in the literature under different practices due to the aspect of variety in setting an organizational culture that ease the compliance and uniformity across all the organization stakeholders.

There are many lean practices used for various objectives that are ranging from non statistical approaches like Kaizen, SMED, VSM, to statistical analytical methods such Six sigma. To use their full potential they should involve the participation of all stakeholders of the organization.

Rosas et al., [20] implemented 5s in 66 Mexican organizations and found that greater commitment from the top management is essential to lead in the creation of an organizational culture, and 5S practice should be included in the strategic planning of the organization. Further training is needed to enhance the perception of the 5S practice and adopt it as a lifestyle rather than a management tool. Moreover, to enhance the 5S implementation: personnel commitment with the 5S practice; the design of official communication channels to know personnel suggestions to improve their jobs; quality and continuous improvement orientation of all activities and operations is essential.

Khamis et al., [11] demonstrated the application of 5s practice is an effective technique that can improve housekeeping, environmental performance and health & safety standards in an integrated holistic way. Effective implementation of the 5S activity depends on the commitment of the top level management, total involvement of the workers and employees at all levels within the company, function and background of the business, publicity given to the 5S activity and finally the training conducted for the organization in implementing the 5S practices.

II. PROBLEM SETTING

A. Statements on the unbalanced workstations - VSM design

In order to locate the main problems existing in the chain, a VSM had to be done. It stands for 'value stream mapping' and is a fundamental tool in every lean manufacturing approach. It is one of the best ways to visualize the different streams within a production (material and information).

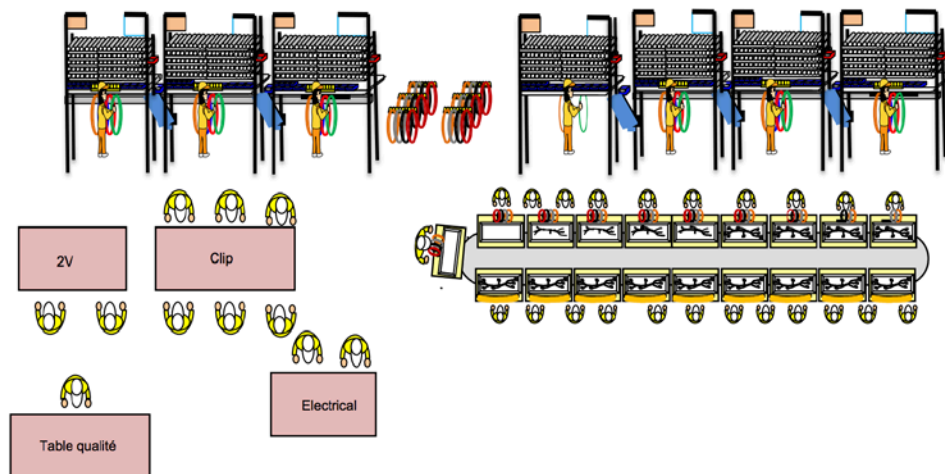
Value stream mapping is a lean-management method for analyzing the current state of some given process or system and designing a future state for its series of tasks or events with a more effective and unwasteful way, that tackles a product or service from its beginning through its final delivery. The VSM graphical approach allows thus the identification and removal of non-value adding activities.

VSM was widely used across the literature in different sectors, however was used with limitation in the wiring harnesses. Two main contributions have been identified in this field.

Dotoli [5] examined in their work how Value Stream Mapping (VSM), the Unified Modeling Language (UML), and discrete event simulation were integrated as a lean manufacturing strategy. The procedure is iterative and hierarchical. Starting from a detailed description of the manufacturing process by the Unified Modeling Language (UML), the VSM graphical approach allows the identification and removal of non-value adding activities. The re-designed manufacturing system is represented in detail by UML to describe the novel system activities. The use of discrete event simulation allows the verification of the updated production system. Applying the lean manufacturing strategy to a real case study shows its effectiveness.

Authors in [3] demonstrate an application of the VSM methodology in electric wire-harness industry through a methodology which integrates the job release methodology (JR) and job scheduling on parallel machines. The application was based on 120-day production data and demonstrated that the proposed methodology provided 25% decrease in in-plant manufacturing lead time.

To set the VSM design, the following production line of electrical wires has been investigated:



There are 7 operators in the insertion part, 11 operators in the layout, 12 in the taping, 6 in the clipchecker, 2 in the electrical test, 2 in the 2nd visual and one quality responsible. The 41 operators work 450 min (7h30min) per day.

Once VSM design is done, it's easy to highlight value adding tasks and identify the different types of waste they could generate such as wasteful processing and overproduction.

Value adding tasks are as any activity that physically changes the shape or character of a product or assembly. As opposed to added value tasks, non added value task is any activity that does not change the product or assembly and that is the perceived as wasteful and ineffective.

The previous line's VSM gave us the following:

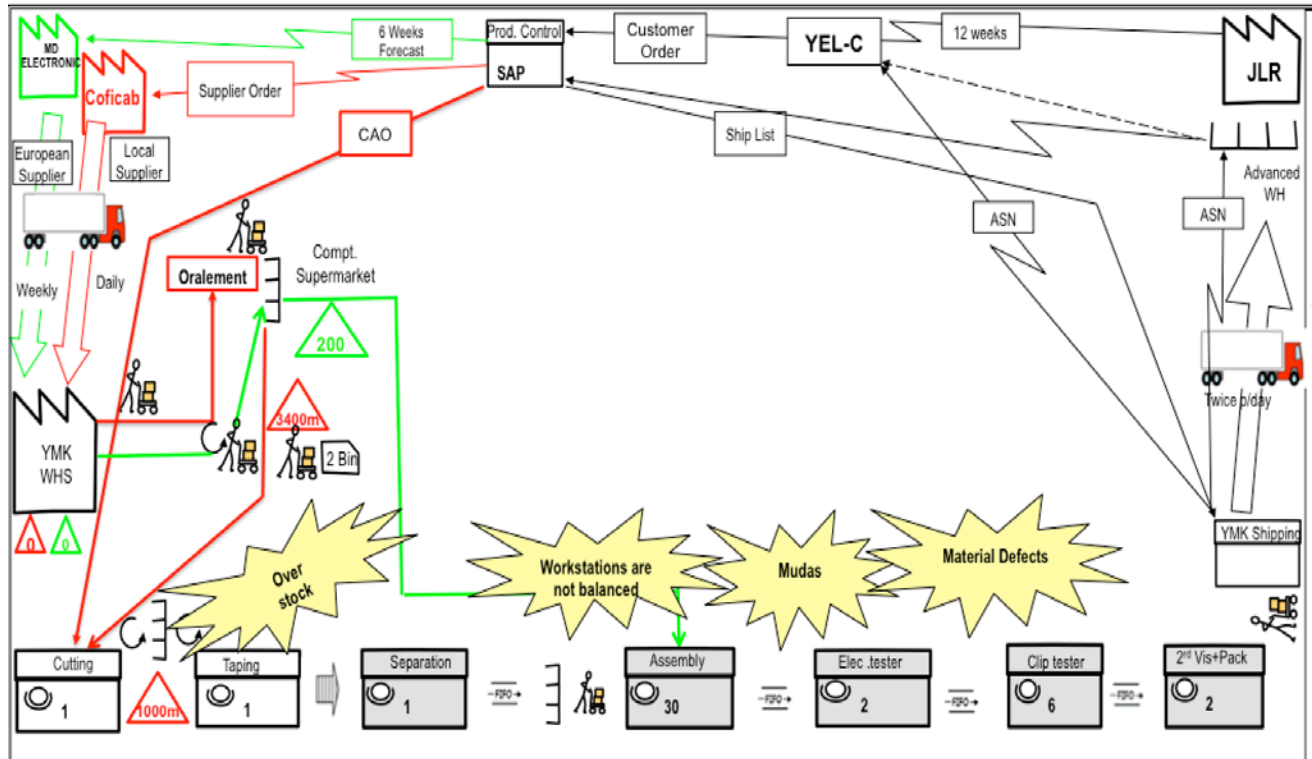


Figure 1: VSM Design

B. VSM Analysis

After the presentation of VSM design of the current status, it was made clear to all the workers the urgent need to develop new practices to improve the current status. It was also essential to explain that those new practices are important for the assessment process and for the improvement of the quality of the production. It was hoped that asking for their help and cooperation was the key factor for improving the implementation success.

A detailed field observation and the analysis of the above VSM allowed noticing the following anomalies:

- ➔ Unbalanced workstations in the assembly part;
- ➔ Material defects;
- ➔ Muda's such as time wasting, operators waiting, and unnecessary motions.

Those issues triggered the deterioration of the line of production and thus the customers' demands in terms of number of cables were no longer achieved.

The direct productivity ratio is an important percentage used in the evaluation of a manufacturing line's performance. It is calculated using the following formula:

$$DP = \frac{\text{Quantity of cables produced}}{\text{Direct worked Hours}}$$

with : **Direct worked hours = (hours per shift – 1h authorized stop)**

In this line's case, the customer's demand was the production of at least 200 cables. However, a 135 cables were manufactured, which gives us:

$$DP = \frac{135}{(41 \times (7,5 - 1))} \times 100 = 51\%$$

In order to deal with the problems mentioned and thus increase the direct productivity, some immediate improvements were necessary. First of all, throughout each and every procedure analyzed, it was remarked that both 'added value' and 'non-added value' ratios were slightly even in some stations and considerably different in others. In order to optimize those posts, the first strategy adopted consisted of reducing the performing time of the 'non added value' actions. However, it was also noticed that some operators were taking too much time to insert, layout and tape. This was mainly due to slow work, laziness, chatting and especially to overloaded procedures.

This motivated the adoption of the strategy consisting of reducing the cycle times of bottleneck stations by not only decreasing the 'non-value added' actions' times, but also by the removal of some of the 'value added' operations in these stations and adding them to less loaded posts. This helped to correctly balance all stations in the assembly line by readjusting their overall time.

III. KAIZEN ACTION PLAN AND RECOMMENDATIONS

A. Kaizen Implementation

Kaizen is the practice of continuous improvement. It refers to activities that continually improve the company's overall functions and involve all employees from the CEO to the assembly line workers. It does not target perfection because no progress, product, system or structure ever achieves the ideal where it cannot be improved anymore.

Nowadays, Kaizen is recognized worldwide as an important pillar of an organization's long-term competitive strategy. Some of its guiding principles are:

- Good processing brings good results;
- Seeing for yourself to grasp the current situation;
- Speaking with data and managing by facts;
- Taking action to contain and correct root causes of problems;
- Working as a team.

LITERATURE KAIZEN

Kaizen has been widely used in various fields ranging from industry to service but more especially in manufacturing areas. Many researchers explored the Kaizen direct benefit on the improvement of the delivery time and the overall productivity level, like Brunet and New [2], Chen [4], and Masud [13].

To reduce operational cost and improve efficiency by Boeing Commercial Airplane Company, the strategy adopted was Kaizen as (Modarress et al., [14]). Glover, Liu, Farris, Van Aken [7] conducted an empirical study to observe the characteristics characteristics, including outcomes achieved, program attributes, and implementation problems, of 16 established KE kaizen event programs.

AL-Tahat and Bwaliez [1] presented an application of lean practices in construction sector, and showed the relation between workforce management system (WFMS) and lean production (LP) that was statistically investigated for ten Jordanian manufacturing sectors. The best implementation level has been accomplished by 'construction' sector and the worst implementation level has been accomplished by 'engineering industries' sector. Findings of this paper can be used to manage challenges opposed to the execution of lean-based WFMS in many manufacturing firms.

Jignesh, Darshak and Rohit [10] presented a concept and methodology of Kaizen named "Kaizen Idea Sheet Format" is describing a step by step implementation of the methodology.

Gupta and Jain [8] demonstrated that the implementation of 5s and Kaizen results in increased efficiency and effectiveness in the production processes of a small scale manufacturing organization. Moreover, it results in improved visibility of the process, improved morale and safety of the employees, reduced delays, searching time and dangerous conditions. The success of 5S and kaizen system is subject importantly to participation, commitment and support from top level management.

Gupta,verma and gupta [9] presented a case study using a simple approach to create the teams for implementing 5S. It has been proved that implementation of '5S' resulted in overall improvement of the organization via tools searching time has been achieved. Tool searching time from shop floor has been reduced from 40 minutes to 5 minutes. '5S' audit has been conducted in the organization. '5S' audit score has been increased from 7 (week 1) to 56 (week 16).

Rahimi et al., [15] employed 5s components in department of youth and sports of Isfahan physical education organization. The study demonstrated that the organ needs to improve the level of standardization in the work place. Standardization in the organs leads to increase in the immune condition, decrease of the dangerous benefit, decrease as the price and waste increase of the effectiveness, satisfy the customer, and improve the operation and good management. So according to the important role of this subject and because of the lower level of standardization in the office of sport and

youthfulness of Isfahan and for improving the quality of the work and increasing the effectiveness of the organs, this office needs to use the new and effective ways to increase the level of standardization.

Rahman et al., [16] applied 5s audit in order to assess implementation of 5s practice in two manufacturing companies. Study concluded that although both companies A and B perform an excellent 5s practice, still Company A score 90.48% which is more than Company B with 72.35% and also there are a few weaknesses that still need to be considered such as arrangement of the documents, tool and equipment.

Sorooshian et al.,[17] implemented 5s in some basic environment problems at Milad Company and found that 5S will foster teamwork, discipline and will increase the sense of responsibility and compassion for company. 5S is an ongoing need to maintain excellent service delivery performance. Assessment of Internal Audit will normally move the organization to continually repair the quality and effectiveness of services delivered to customers.

Urban and Mazurek, [19] did their study in Bianor, a polish manufacturing company and found that the application of the 5S method has allowed the creation of a clean and tidy workplace, virtually without large financial input. It contributed to the introduction of the company’s new way of thinking and new values. The company has made a significant step towards perfection. Employees cooperated willingly in creating the new rules and standards, and therefore, their awareness of the importance of maintaining order in the workplace has increased considerably.

Other research work investigated the utilization of Kaizen in other fields like education, such Emiliani [6]. In service organizations, Lokkerbol, Does, Mast, and Schoonhoven, [12] used the improvement process in finance, namely the improvement of financial system in financial institutions. AL-Tahat and Bwaliez [1] presented an application of lean practices in construction sector, and showed the relation between workforce management system (WFMS) and lean production (LP) that was statistically investigated for ten Jordanian manufacturing sectors. The best implementation level has been accomplished by 'construction' sector and the worst implementation level has been accomplished by 'engineering industries' sector. Findings of this paper can be used to manage challenges opposed to the execution of lean-based WFMS in many manufacturing firms.

In the current study, to analyze the efficiency of Kaizen implementation, some metrics have been recorded like that tact time (TT). Before taking any action, a Yamazumi chart needs to be done to locate the different bottlenecks. It is a visual tool used within lean manufacturing to aid in cell design and continuous improvement of a production. It allows the visualization of various work elements within a process and compares them to the required customer demand also known by takt time. The latter is the speed at which the factory should run to meet customer’s demand.

To do that, the operations performed by every operator need to be timed, using a stopwatch, to set their overall cycle time. For this particular line, the Yamazumi board is:

The red dot represents the average value of the different cycle times (‘takes’) recorded in each operation. A red line is drawn across to indicate the takt time for the process. In our case, its value is 138s and is calculated using:

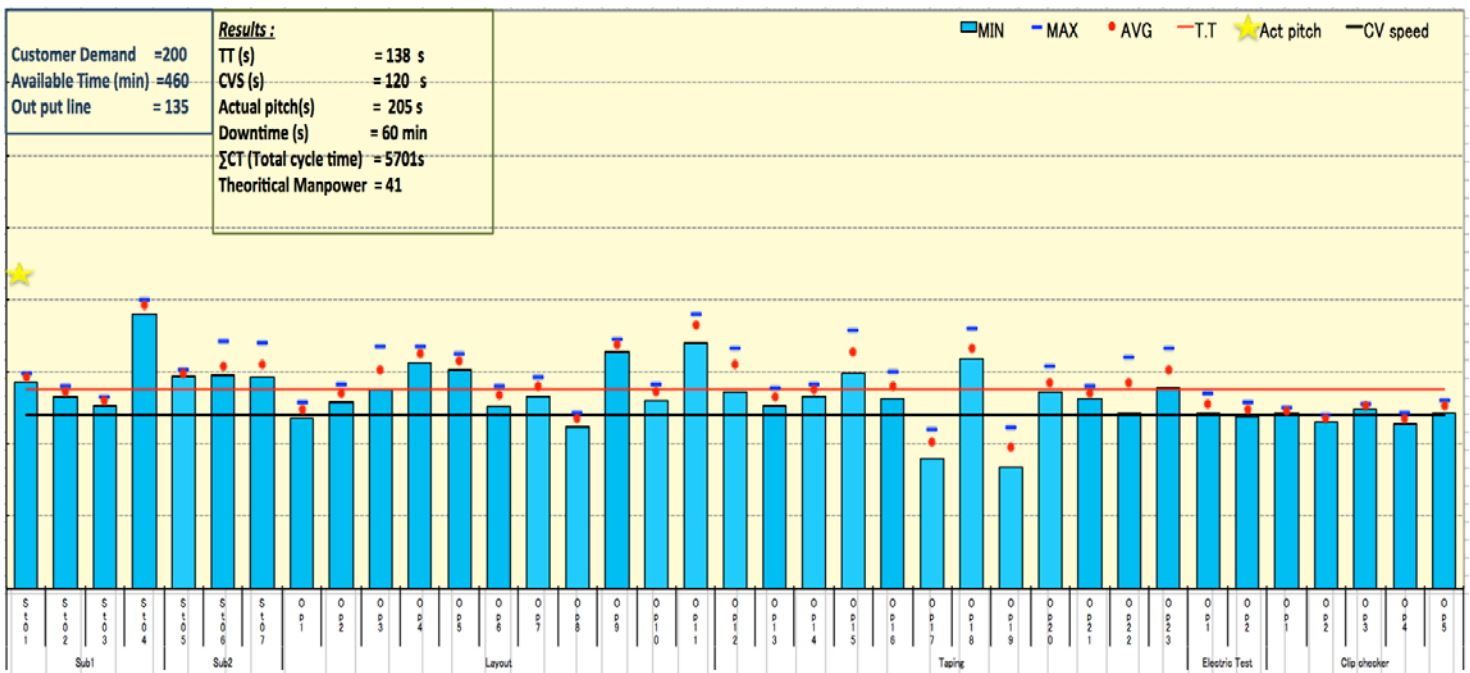


Figure 2: Yamazumi Chart

$$Takt\ Time = \frac{Available\ Time\ for\ Production}{Customer's\ Demand}$$

$$= 138s$$

It is also noticed that the line of production isn't balanced. There is a huge difference in amplitude between the different tasks meaning that some operations take way more time than others. This shows the existence of various bottlenecks (18 in total).

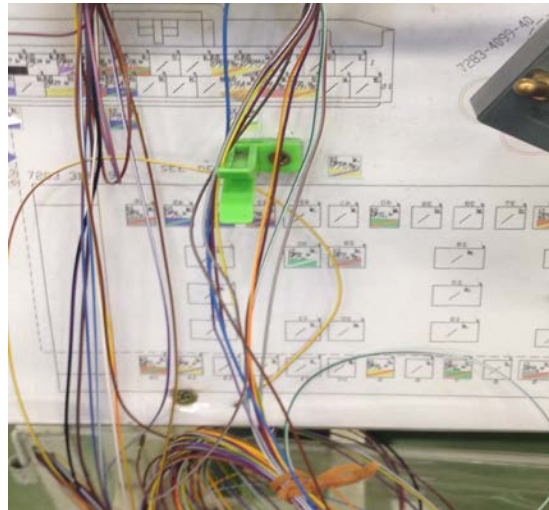
The Yamazumi chart provides a mechanism to quickly rebalance a process when takt time changes, and allows a visual indication of which operations are overloaded, and which ones aren't. The aim is to ensure that all operators' workloads fall below the takt time.

After re-observing the assembly line closely, some recommendations raised to brainstorm adequate solutions. The actions agreed upon are the following:

Table 1: Actions by Stations

Area	Actions	Stations
Insertion	Balancing.	All insertion stations (St01-> St07)
	Reestablish sequence with operator. (Explain to the operator how to correctly perform the operation illustrated in the plan)	St04
	Rearrangement of wires' ends (wires are very long and thus tend to fall back their location in the tubes. We had their ends repositioned in the tubes to avoid that.)	
Layout	Balancing	Op6 - Op5 - Op4
		Op2 - Op3
		Op7 - Op8
	Changing the method of separation and tracking (layouting) of wires.	Op9
		Op11
Taping	Lubrication of forks. (Using special oil. The forks tend to be stiff and difficult to relocate)	All taping stations
	Balancing	Op11 - Op13
		Op15 - Op14
		Op16 - Op17
		Op18 - Op19
		Op21 - Op22 - Op23

It was also decided on changing the emplacement of the wires' hooks on the jig (from up to bottom) as well as adding green pins where the cables could be put. This will facilitate the procedure for the operator and prevent wire separation problems that occasion tardiness in cables processing. The following pictures illustrate these specific changes:



used to the workers to work eff

For the stations that needed balancing, the changes thought were necessary were applied by removing operations from one post and adding them to the other. The details are put in the following table:

Task	Ancient Station	New Station
Insertion in cavity 2 of connector 19	St 01	St 02
Insertion in cavity 8 of connector 20	St 04	St 03
Insertion in cavity 7 of connector 20		
Insertion in cavity 5 of connector 20	St 04	St 02
Insertion in cavity 6 of connector 20		
Insertion in cavity 1 of connector 23	St 05	St 03
Insertion in cavity 9 and 8 of connector 38	St 07	St 06
Insertion in cavity 1 of connector 64	Op 3	Op 2
Insertion in cavity 1 of connector 48	Op 3	Op 1
Insertion in cavity 4 of connector 16	Op 4	Op 2
Insertion in cavity 5 of connector 16	Op 4	Op 6
Insertion in cavity 15 of connector 63	Op 5	Op 6
Wrapping of branch (linked to conn 16,45,46)	Op 11	Op 13

Wrapping of branch (linked to conn 33, 66, 64)	Op 15	Op 14
Wrapping of branch (linked to conn 17,43,42)	Op 16	Op 17
Wrapping of branch (linked to conn 16,45,46)	Op 18	Op 19
Wrapping of crossing cables	Op 22	Op 21
Wrapping of branch (linked to conn 14,99,98)	Op 23	Op 21

In addition to that, the operators need to be gathered in a brief meeting so as to talk to them about the importance of their input. They need asked to talk less, walk efficiently and avoid any unnecessary action while working. This will reduce the time -wasting observed, and thus help produce more cables in less time and raise the productivity ratio. Motivating them and explaining how each detail of their work affects greatly the output of the line were one of the many effective ways that helped reducing waste.

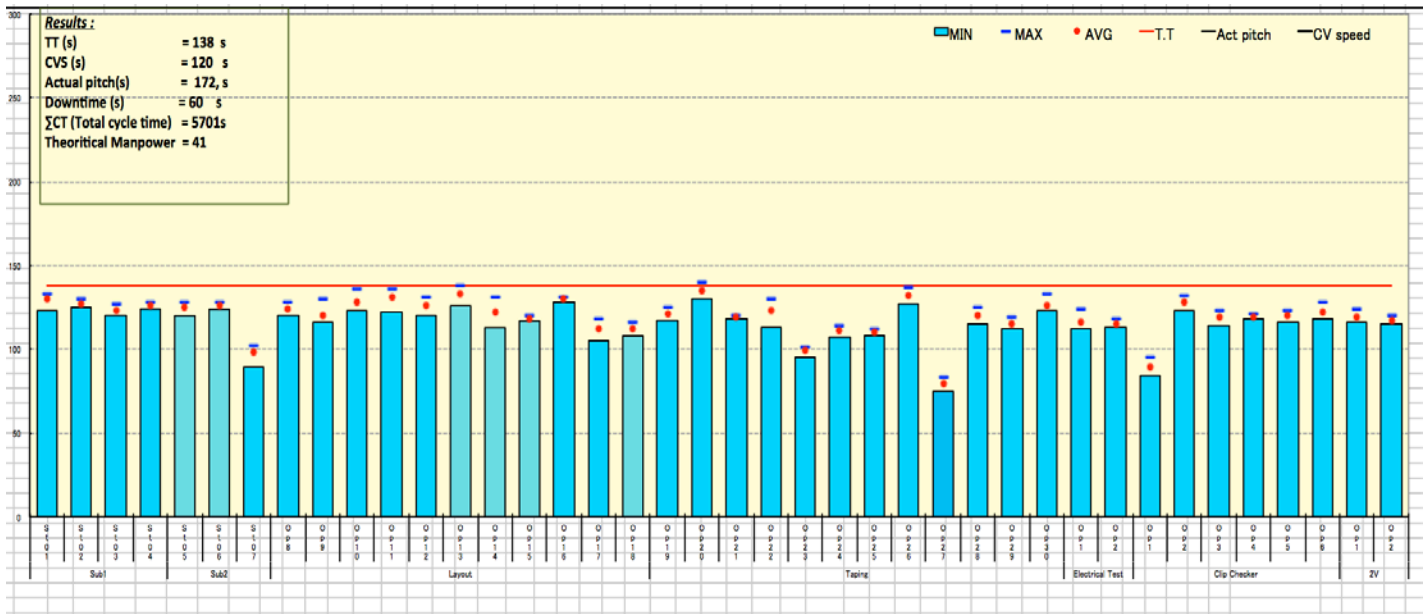
Concerning the problem of material defects noticed, the most obvious and suitable solutions were:

- Changing all the worn wires detected.
- Establish routines for replacing old batteries with new ones regularly
- Establish routines for cleaning up the machines frequently.

Some recommendations have been addressed to maintenance department as well. The recommendation requested that regular inspections on the machines used should be done with a routine-based at least twice every week in order to prevent any kind of tardiness in the manufacturing of the cables.

B. Results of the Kaizen action plan on the production process improvement

After applying the solutions suggested, each bottleneck, along with every operation at every post, needs to be re-timed



before performing the line's new Yamazumi chart. The results are as follow:

As noticed from the new Yamazumi, the stations stabilized below the takt time and a huge gain of time was observed in every bottleneck that was dealt with. Also, the line with the same shift (41 operators) produced a total of **274 cables**, which is

a 139 more cables than what was recorded.

This gives us a direct productivity of:

$$\frac{274}{(6.5 \times 41)} \times 100 = 103\%$$

CONCLUSION

The case study conducted at a wiring Company is successful. Firstly, the study aimed time waste towards the productive improvement. First, time losses at production were identified and improvement solutions were proposed. Finally, the effect of improvement was measured by comparison of lead time before and after improvement. All the cycle times were stabilized and the line's productivity has known an increase of 52%. In fact, it got better and became more efficient by producing more in less time thanks to the solutions and Kaizen approach applied.

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BIOGRAPHY

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