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István VAJNA, Anita TANGL

1.6. THE LEAN EFFECT OF THE 5S AND STANDARD WORK DEVELOPMENT IN DIFFERENT AUTOMATED MACHINE PROCESS STANDARDIZATION

Summary
The Standardized Work (SW) means to create wasteless process as much as possible and create the document of the current best practice to maintain the developed status. SW is the baseline for KAIZEN. As the standard is improved, the new standard becomes the baseline for further improvements, and so on. Improving standardized work is a never-ending process. In this
Our research shows how can be combined the 5S and standard work. By the parallel implementation of the 5S and Standard Work, the economic benefits are coming earlier.

Keywords: lean, standard work, 5S

The Lean Concept origin

All business-oriented company's primary goal is to gain profit even if it is a production or service provider company. Either the micro or multinational companies act in a characteristically and locally specialized but continuously changing business environment. Despite that, there is an open market by globalization for everyone, the immediate local economic, political, social, geographical, energetic, environmental factors strongly influence and define the market share. In one hand, the profitability of a company lays down the ability of effectiveness of the company's internal business processes and the adaptation capability to the external business environment, during the companies different lifecycle stages (Illés et al., 2015). On the other hand, this means that how much value is created during the transformation process and how much non-value added activity and waste is hidden in the value stream of the business. Waste means all activities that will not add value during the transformation process and service. The value added and waste ratio strongly define the income flow and quality as well as the costs. The costs directly decrease the profit. (Illés and Szuda, 2015; Al-zaidi and Dunay, 2015)
This thinking has roots in Arsenal of Venice in the 1450s at starting of mass production. This ship factory was capable of producing one fully equipped merchant or military vessel per day, whereas production of similar sized and featured ships elsewhere in Europe took several months. At the Arsenal, the modern concepts of standardized parts, assembly-line production, specialized work groups, and vertical integration were anticipated. The modern era's mass production systems started to develop in 1890s. In 1905, Henry Ford together with his chief construction and production inventor József Galamb designed the mobile assembly line for the Ford T-Model. In 1937 in Japan, the Toyota Motor Corporation was founded by Kiichiro Toyoda, son of Sakichi Toyoda. Toyota adopted a new business paradigm for the

profit realization and it was led by a strong process thinking in the manufacturing by entering in deep details, managing by facts on the Gemba. The basic principle was – and it is the same in our time – is eliminating the 3MU, i.e. Mura (unevenness), Muri (overburden) and Muda (waste). (Shook and Marchwinski, 2014)
The concept and methodology was always perfected by Toyoda and by time it has been developed into an effective business system called Toyota Production System (TPS). The backbone of the business system stays in systematic method for the elimination of waste. Everything that does not add value for product or service from the perspective of the customer shall be considered as waste. All the things what are done by the human beings or by machines during the whole worktime and everything becomes the part of the so called value stream, or someone is doing value added work, or moving. In the business environment, there are many ways to increase productivity. In the Lean production there are two main approaches: the continuous improvement known as kaizen and innovation (buying new technology) or combination of these. The one of the most effective business philosophy is known as the Toyota Production System-TPS- published also in Toyota Way. The TPS is responsible for the production or service to ensure flow of quality and Kaizen (Imai, 2012).

The Lean principles

The key element of the Lean production is to be able to identify two things in your business activity area and business processes, namely the value itself, and to make difference between value and waste. Value is that for which the customer is willing to pay and all other things in the sense of the business result are to be considered as waste. Seven main waste (it is called 'Muda' in Japanese language) are differentiated:

1. Muda of Over-Production;
2. Muda of Waiting;
3. Muda of Transportation;
4. Muda in Processing (i.e. over-processing);
5. Muda in Inventory;
6. Muda of Motion, Movement;
7. Muda of Correction (scrap, defect).

In any corporations and business activities these wastes are always presented in some ratio. The best ratios in the world are connected to production companies with Toyota production where in the value stream during the total lead time the VA (value added) is 5% against the NVA (non-value added) activities what is 95%. In the Japanese business sense this is a potential or possibility which may solve the problems gaining profit by sparing costs.

The meaning of Lean manufacturing in practice

The Lean manufacturing means to make effort day by day to recognize the value and the waste in processes and to apply in and in practice the five basic rules of the Lean production. (Womack and Jones, 2009)

1. Specifying value from the standpoint of the end customer by product family. Identifying the value for the customer.

2. Identifying all the steps in the value stream for each product family, eliminating whenever possible those steps that do not create value.
3. Making the value-creation steps in tight sequence so the product will flow smoothly toward the customer
4. As flow is introduced, let customers pull value from the next upstream activity.
5. As value is specified, value streams are identified, wasted steps are removed, and flow and pull are introduced, begin the process again and continue it until a state of perfection is reached in which perfect value is created with no waste.

The total value stream means the observation of the business processes on different scale from the customer order until the payment of the service or the product. In order to find the problems which may stop the flow or decrease the quality the processes will need an investigation on different levels. The macro level is 10,000 foot view so a very broad overview of the business processes or even down to the micro level. The micro level means to analyse the work processes in the given work environment considered by the rules of 5S. After eliminating the Muda the more developed work process is called standardized work (SW) and standards are to be created in order to maintain the work operations time and quality.

The problem solving by OPPDCA and 5S

The meaning of the problem is depending on the user community. The definition of the problem by the (Webster dictionary) is: a question raised for inquiry, consideration, or solution. In the Lean concept problem is any difference between the actual status and goal. To search and solve problems of the Muda is needed a basic project tool helping the team to act effectively. It was used the Deming PDCA cycle and the OPPDCA (OPPDCA stands for: Observation, Pre-check, Plan, Do, Check, Act). This is an extended methodology of the PDCA when is intensive Kaizen action to reduce the risk and increase result during the completion of the 5S and SW development.
The 5S means the structured methodology to create and maintain the high quality workplace in 5 steps. 1S (Seiri) means to eliminate the unnecessary items 4M+ (Man, machine, Material, Method) and information. The 2S (Seiton) arrange everything in the right order for the process, 3S (Seisou) Clean and check everything, 4S (Seiketsu) set the most right rules, 5S (Shitsuke) means to practice the 1S to 4S cycle like mind-set. In the TPS system gives the stability and foundation for Kaizen is given by 5S followed by the SW (Standardized Work) development (Vajna and Tangl, 2015).

The elements of the standardized work and the Standard Work development

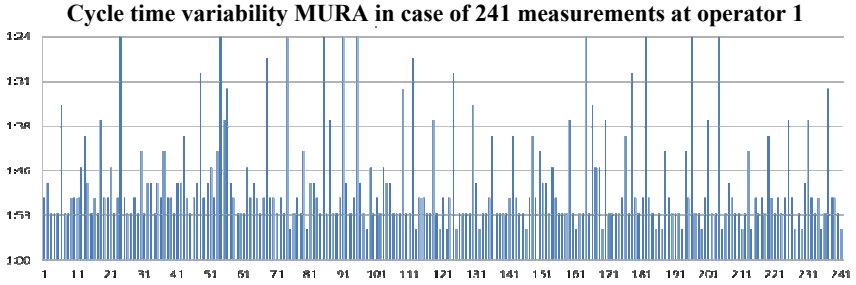
Standardized Work has three main elements:

- Takt time – the quantity rate – at which products must be made in a process to meet customer demand
- Standard work sequence – precise balanced work sequence that operator performs within the takt time
- Standard WIP (SWIP) .e. Standard work in process or SWIS i.e. standard work in sequence is the inventory level of all units in the process (including machine) for smooth operation (Vajna and Tangl, 2013)

The current statement analysis

The Standardized work development was five days. One day training followed by four days on shop-floor (Gemba in Japanese). The management decided to increase productivity of the manual operations of three operators at three different the low pressure system moulding machines. The PDCA cycle of the development process included the diagnosis and the treatment. After half-day observation and understanding the work elements and technology the standardized work study was continued with the deep numerical /statistical data collection. The independent data collection was made continuously by six persons (two in pair) trained and led by the Lean Kaizen expert on the shop-floor during the whole worktime. There were made minimum 240-250 cycle time measurement for each operator (Figure 1) for one batch processing processed by one operator on three different type machines and products.

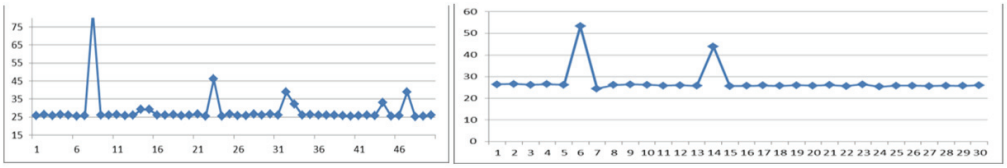
Figure 1: Cycle measurement.



Source: own measurement

On next day the operators were interchanged between the machines, but during the whole workshop the operators were the same physical persons (Figure 2). The data collection included the machine operation and stability analysis. The data collection was run for 2.5 days. Out of some cycle time errors the process revealed that not the machine, were the key success point of the development but revealed some hidden improvement points, too.

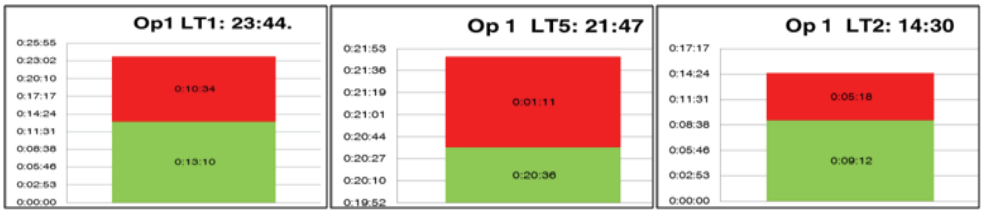
Figure 2: Machine Cycle time on operator 1 and operator 2



Source: own calculation

For data collection the standard for work time collection of data sheets, stopwatch and continuous video recording were used from three different axes to see both hands in operation, the work piece/tools, the machine operations and wastes during the processing. It were counted all inputs and outputs manually and cross-checked. The scraps were also registered. The workplace was also evaluated with 5S point of view. The implementation phase took only 1,5 days including checking and corrective actions. The loss times is visualised in Figure 3.

Figure 3: The loss times and the high inoperability ratio due to lack of SW during small batch processing

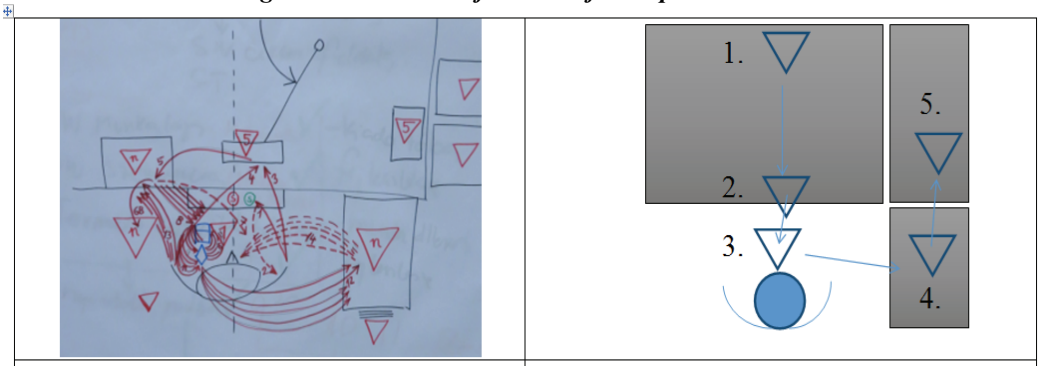


Source: own calculation

The process of creating standardized work

After data collection, all data were visualized and analysed in graphs, pie and line charts, and was performed statistical measurements. The research on low pressure injection moulding machinery The general process of moulding product: 1. raw material stock handling, 2. raw material transportation, 3. mixing raw materials 4. heating up, 5. transportation to moulding machines, 6. the injection moulding by machine (VA) 7. optical quality check by operator, 8. manual postproduction processes, 9. batch creation. The processes 6.,7.,8.,9 were examined in depth. In step 6, one moulding process resulted 4 to 6 pcs. of product depending on the moulding form. Each pieces were processed one by one to cut the roughness by the operator. The processing also resulted not only time waste but also quality problems. Produced good quality in one shift was 1892 with 916 scrap. The reusable raw material quantity and quality was not measured and considered at all thinking that after reheating and reprocessing will result good product, but not to after the right first. Operation 6 was the only one value added (VA) activity in all other 41 motion/transport, check and correction is waste. There were 11 different WIP locations with big quantity (total 89 pcs) of materials and always variable. After development the WIP was reduced to 5 locations (Figure 3.) with single piece (in 1. machine inside – transportation → 2. machine outside, 3. in operator hands, 4. packing box, 5. place for quality sample after each 500 pcs).

Figure 3: The WIP before and after improvement



Before	After

The comparison of the results of the 5S and SW improvement in the before and after stage of development is in the Table 1.

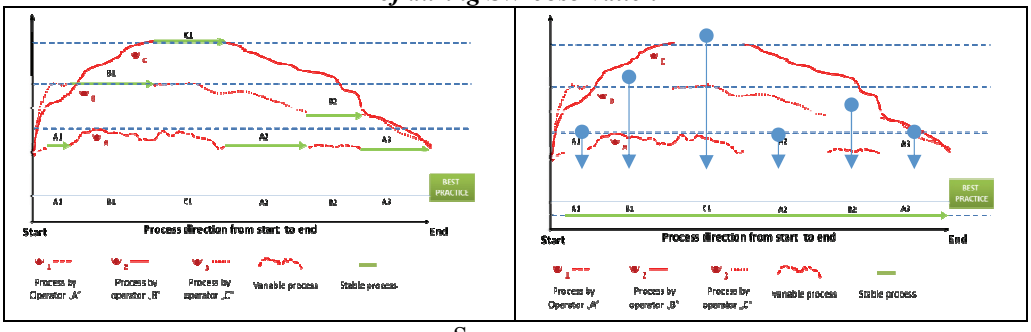
Table 1: Comparison of the results of the 5S and SW improvement in the before and after stage of development

Before	After
Processes VA/41 NVA 0,00	1VA/ 8 NVA
Long and variable way of processing, no visual standards and obstacles in work area.	Direct POU to POU movements in small batch check and processing in once. Stable manual support and work sequence
Not adequate and quality hand tools	High quality prechecked tools.
1892 psc. good with 916 scrap, (48% scrap)	Output: 2905 psc good+1313 better products = total of 4218 pcs and 132 pcs scrap only
Rework time and capacity loss	No cost of opening new shift, bo time delay
Demotivated and nervous employees	Motivated operator that without stess and effort has better performance
From 2:05 operation hours 30 minutes total lost time from forced stop of the machine	Continuos machine operation

Source: own calculation

The visualization of the time efficiency / and MURA of the three different operators work during the process observation before creating the SW. By selecting the best work sequences from each operator and combining in the right sequence resulted the waste elimination and improvement in productivity.

Figure 4: The visualization of the process efficiency in time of the three operators (A, B, C) of during SW observation



Source: own

The Figure 4 shows the visualization of the process efficiency in time (x, y) of the three different operators (A, B, C) of during the standard work observation. Creating the SW was performed by selecting the best operation elements from each operator work and combining into a new better practice gave a much better result than copying the best operator performance sequences. Later this analysis method was used to all kind of analysis of manual work such is Changeovers turning into quick changeover SMED (single minute exchange of die) process.

Conclusions and benefits

Standard work is known mostly to develop the human aspect of the work effectiveness improvement. In the Japanese thinking and acting the right way is to consider all the

elements of the process because everything is related in the man-machine complex and environment. One data is true only in the moment of the analysis. During the development all possible parameters were registered and analysed. To get the best results it was necessary to use scientific methods. To improve empirically and observe only the best operator should not gave such results. The productivity of the "best one" process should limit the boundaries. The best performer does not mean the best opportunity. Age, sex, work-experience seems to have no significant effect on output. Even in the worst case of the analysis the productivity was raised to 222%. Annually this gave extra 306.000 pcs. of product per product type for one operator.
5S and SW together are powerful Lean tools. Without implementing 5S in these workplaces itself the analysis should not give such results. All unnecessary things were removed from the operator's range, the necessary tools were procured, the chair changed to adjustable chair for each operator. The surface of work area was improved by making more safe and ergonomic. The mechanical arm of machine was redesigned by operators and technicians for smoother operation that not dropped the WIP.
The work was standardized and was set new work standards on the shop floor:

- Operation balance chart
- Production capacity sheet and board
- Standard operation work chart
- Standard Combination Work Chart
- 5S method and clear visual standards were set
- Standard work Tools and cleaning tools were set up with a 2" rule availability
- All three operators were trained and could perform with 5% variability all processes.

Besides the financial benefits the 5S and SW improvement had more positive outputs:

1. Consistency (reduction of variation) among staff members performing the work balanced and in same way. Induction of Training development programs.
2. Reduction or elimination of errors and human mistakes (causes of defects)
3. Work process stability, reduced defects and waste in process
4. Increased employee safety (no even minor injuries)
5. The order can be fulfilled without extra shift
6. Operation with less cost on higher productivity
7. Employee involvement and empowerment to make changes based scientifically
8. Improved productivity without added stress in workplace
9. Encourages flexibility and creativity between the operators
10. Improved, and much higher quality
11. Improved cost management as wastes are removed,
12. Availability of a great tool for staff training
13. Visual management--managers and supervisors can see when processes are not operating normally.
14. Frees managers and leaders to focus on strategic objectives
15. Makes improvement easier and faster
16. Makes results predictable and measurable

The research shows clearly: there is not only one way to improve productivity using standard work. The empirical development hides costs and lack's the productivity by

blinding the management from the real opportunities. The 5S together with SW development has much stronger effect in Kaikaku way (intensive short time improvements) involving directly the stuff in cross-functional team. The standardization techniques application must be chosen by the local business environment and implemented immediately and re measured. The SW has to the QCD indicators direct effect. Setting up new work methods cost are six times less than in the empirical way. The results are indisputable. The audits can be performed much effectively and redesigning a process lead-time is shortened. The improvement ideas are given much wisely focusing on QCD elements. Monitoring the performance during the shift and reporting gives more accurate data and the visual control helps everyone in decision taking. Ensure the necessary measures are taken alerts support functions, by developing effective real training materials and defines performance of the improvement possibilities of human limits. Daily operation of SW ensure that standard less variable work gives much more stable output. The Combination of the existing scientific results can lead to better results. Where 5S and SW was extended the ROI was 50% higher. The problem solving can be founded and operated in a company with implementing easy to understand visual methods from operators to top management with common understanding towards the customer satisfaction.

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