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Current State of Standardized Work in Automotive Industry in Sweden

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Abstract

Standardized work has been one of several larger research topics in the automotive industry over the years. This paper gives a brief view of the current situation of standardized work in the automotive industry in Sweden. The paper is based on recently performed studies at several automotive actors in Sweden. Most of the present research about standardized work focuses on local premises. Therefore, this paper suggests more focus in future research on how to implement standardized work in global organizations focusing on local demands and cultural differences and similarities.

1. Introduction

Standardized work is one of the most important parts of the Toyota Production System (TPS).

As Liker and Meier [1] cite Masaki Imai:

“...there can be no Kaizen without standardization”.

Kaizen is Japanese and means continuous improvements. Standardized work, standard work or even standard operation procedures have been written about for quite some time. Despite the great knowledge of how to work with standardized work and continuous improvements, many production sites still work in old fashioned ways. Today, the automotive industry is facing a more instable world market which emphasizes the need of establishing a more effective business, which means that cost needs to be minimized and quality at the same time to be increased. The success of using lean manufacturing in the east has influenced the manufacturing industry in the west to implement lean thinking in their business.
2. Reference framework

This chapter captures the framework of references used to analyze the current situation of standardized work in the Swedish automotive industry. The chapter is organized in four parts as standardized work, Kaizen, mass customization and modularization.

2.1. Standardized work

As most books about lean manufacturing, Liker and Meier [1] begins the chapter about standardized work with the misunderstanding and differences between standardized work and work standards. The question is whether it is a misunderstanding or not. What is the source to the standardized assembly instruction? For a production preparation engineer to be able to design the assembly instruction, and being able to perform line balancing, the different actions (both value adding and not value adding actions) needs to be measured by time. This should not be mixed up with Taylors Scientific Management [3] which was criticized for disregarding social benefits for measurable benefits. [4]

MacInnes [5] defines on page 64, eight steps to develop standardized work:

1. Establish improvement teams.
2. Determine your takt time.
3. Determine your cycle time.
4. Determine your work sequence.
5. Determine the standard quantity of your work in progress.
6. Prepare a standard workflow diagram.
7. Prepare a standard operations sheet.
8. Continuously improve your standard operations.”

According to Liker and Meier [1] there must be a certain kind of repeatable work to be carried out, being able to standardize. If the actions are more of an event triggered manner standardized work is not a suitable solution. Liker and Meier also states that there must already be a certain quality level in the production otherwise it could be hard to see the real benefits of using standardized work if the operators are fixing irregular deviations in the production flow. [1]

Product and production must have reached a certain degree of maturity being suitable for applying standardized work (i.e. being able to see benefits of standardized work).

Creating the standardized work documents, the work steps need to be identified and recorded using a standardized work combination table which states work elements, time elements (manual, auto and walk) and the operation time as a graph. [1] [5] [6] The standardized work sheet used by the assembly workers contains work elements, work time, walk time and a workflow diagram. [1] [5] [6]

One of the most important parts of the concept of standardized work is doing continuous improvements. Audits are used as a tool to detect potential improvements. [1] [5]

2.2. Kaizen

Kaizen, previous explained as performing continuously improvements, is one of the most important parts of standardized work.

As MacInnes [5] states:

“It is through the continuous improvement of your standard operations that your organization can systematically drive out waste and reduce costs.”

Pine II et al. [7], defines continuous improvements as cross-functional teams that with coaching by managers improve their processes to lower costs and increase quality.

According to Imai the concept of Kaizen contains several well-known approaches to improve quality in execution. See the so-called Kaizen Umbrella in Fig 1. [2]

Imai states some of the features which specify Kaizen [2] as:

- Long term effects,
- Small steps,
- Involve the entire organization,
- Maintenance and improvements.

2.3. Mass customization

Hart [8] describes mass customization as the possibility of providing a customer with the product they
want anywhere, anyway and at any time, seen from the customer side. From the manufacturer side, the processes should be flexible, being able to produce unique and customized products at low costs.

According to Pollard et al. [9], the key success factors of mass customization are lower cost and customize products on large scale.

Modularization (described in the next subsection) according to Nambiar [10], is the key stone for being able to implement mass customization in the organization, as it fulfills the flexibility requirement for implementation.

The flexibility in the organization can be established by having a flat organizational structure with cross-functional integration. [9]

As Hart [8] mentions, three factors that argue for moving towards mass customization are
- Generalization problems of customers,
- Shorter product life cycles,
- New flexibility options available.

Pine II et al. [7] states that to be able to use the concept of mass customization, kaizen needs to be implemented within the organization.

Pollard et al. [9] state four approaches to apply mass customization as
- Collaborative customizers – The product is customized by the customer, according to a set of regulations set by the producer.
- Adaptive customizers – The standard product is adapted by the customer after the acquisition.
- Cosmetic customizers – The same product has different packaging depending on customer.
- Transparent customizers – Product is customized by the manufacturer without the costumers’ notice.

When defining what modularization is, one can divide the concept into three different views; product range, product and component. [11]

Ericsson and Erixon [11] define the term modularity as:
"...product modularity is defined as having two characteristics: 1) similarity between the physical and functional architecture of the design, and 2) minimization of degree of interaction between physical components."

Pandremenos et al. [12] define three different fields using modularization as design, use and production.

The modularity concept is still different depending on the certain actor. One actor could both have outsourced development and production of a certain module to a supplier, while another actor uses modularity as a way for the customer to choose between some options for a certain element. It always depends on which view that is applied. [12]

3. Standardized work in Sweden

This chapter describes the current situation of standardized work in Sweden. The chapter is organized in four parts describing standardized work instructions, audits, assembly worker involvement and training. For this paper, interviews have been carried out with experienced people within the area of standardized work and assembly instructions as well as analysis of case studies recently performed at different automotive actors in Sweden with connections to the global market. This paper describes current situation at five actors defined as actor A, B, C, D and E. Actor D and E are within the same corporate group and information about actor D and E are based on interviews.

3.1. Standardized work instructions

In the previous chapter standardized work sheets were described, and what information they contain. Today, different kinds of representations of assembly instructions are used in the automotive industry.

A case study performed by Olson and Villeius [13], investigates how the standardized work instructions are visualized at actor A, B and C. At all three actors, two types of guidelines are used. A general sequence is visualized at each station on an A3 printout. At actor A and C the job elements are visualized by using a binder system at each assembly station. At actor B a screen is used to support the assembly worker doing the right things. [13]

Interviews have been performed by one of the world’s leading manufacturer of commercial vehicles.
At one of the production facilities (actor D) standardized work has been implemented recently, using standardized work sheets at each assembly station. These documents are aligned with state of the art described in the previous chapter. At another of the production facilities (actor E) the implementation of standardized work has just begun. Since different interpretations from state of the art exist, the current step is to decide which concept that is to be implemented.

3.2. Audits

Continuous improvements is one of the key stones in standardized work and to be able to perform such actions, audits need to be performed throughout the production to be able to detect potential improvement areas.

At actor A, B and C audits are performed on daily basics and per shift to follow up that standardized work are followed (both on team leader and production leader level. At actor A, audits are also performed by the factory manager. [13] At actor D audits are performed on daily basics to follow up that standardized work are followed on each assembly station. Audits are also performed by the top management. At actor E standardized work is to be implemented.

In standardized work, assembly instructions are frequently updated according to continuous improvements. According to the literature (explained in previous chapter), the entire organization should be involved in the continuous improvements work, from assembly workers up to top management.

At actor A and C, assembly workers are responsible for writing new suggestions to assembly procedures, but at actor B it is the manufacturing engineering department that has that responsibility. [13] At actor D the assembly workers are also responsible for writing suggestions for improvements of assembly instructions. Changes could be due to ergonomic issues or better way of assemble a part.

An example of a potential situation that could lead to a better way of assembling a part could be the situation where part X is already assembled and part Y is to be assembled (option 1 in Fig. 2). When part X is already assembled it is hard to see and reach the assembly point for part Y. An audit detecting quality defects related to this assembly element could lead to a new standard where Part Y first is assembled (option 2 in Fig. 2), and part X is assembled afterwards, removing the vision and reaching issues. More of this will be covered in the subsection about assembly worker involvement.

3.3. Assembly worker involvement

Liker and Meier mention that a common problem with improvements is that the operator is left alone with the new process without any support, which in counter to improvements, can lead to worsening quality of the assembly work. [1] At actor D, an assembly station is not allowed to be operated by an assembly worker that does not know and/or understands the content of the standardized charts and element sheets for the same reasons that Liker and Meier mention.

Actor A, B and C all states that they involve their assembly workers in improvement work. Actor A and C are involving their assembly workers when improving assembly instructions and they are also using a sort of rewarding system to stimulate improvements. The rewarding system is based on deviations detected or suggested changes by assembly workers that have increased quality and/or productivity. [13]

At actor D assembly workers are involved when improving assembly instructions, but also to react when standardized work is not possible to follow (e.g. wrong order in an assembly sequence). Assembly workers are also participating during problem solving.

3.4. Training

Training is important for the assembly worker, not only for a new employed assembly worker, but also for a skilled assembly worker due to process changes.

At actor A, B and C new assembly workers are taught by a mentor or the team leader. At actor A, a three week
long introduction is held for the new assembly worker. It is also stated that the assembly workers get the same education since it is based on standardized work instructions. [13]

At actor C [13] and actor D, competence matrixes are used to visualize the competence of the group on individual basis. At actor D, all assembly workers are educated, and are not allowed to work individually until it is guaranteed that the assembly workers understand and can follow the content in the standardized documents.

3.5. Similarities and dissimilarities between actors

There are some similarities and dissimilarities between the actors previously explained. In Table 1 the actors are compared to each other from four categorizes used to describe the actors.

Table 1. Similarities and dissimilarities between actors.

| Standardized work instructions | Actor A, C, D | General Sequence on chart and detailed sequence are visualized using binder system. |
| Acttor B | General Sequence on chart. Detailed sequence is visualized on a screen. |
| Actor E | Not started with the concept. |
| Audits | Actor B, C | Audits performed on daily basics by team leader. |
| Actor A, D | Audits performed on daily basics by team leader. Audits also performed by top management. |
| Actor E | Not started with the concept. |
| Assembly worker involvement | Actor B, D | Assembly worker involved in improvements work and instructions updates. |
| Actor A, C | Assembly worker involved in improvements work and instructions updates. Rewarding system used to stimulate improvements. |
| Actor E | Not started with the concept. |
| Training | Actor A, B | Training performed before working alone. |
| Actor C, D | Training performed before working alone. Competence matrixes used to visualize team competence on individual basis. |
| Actor E | Not started with the concept. |

4. Discussion

This paper gives an overview of how broad the implementation of standardized work is in the Swedish automotive industry. The level of standardized work varies quite a lot depending on which actor that is evaluated. This paper reflects actors as car, component, truck and construction vehicle manufacturers.

The standardized work concept has been around for quite some time, but still there seems to be room for many improvements in the area. As stated earlier actor E has not implemented standardized work, but has started to analyze those concepts that are already used in the industry. At actor D standardized work has only been used for a couple of years. During this short time of using this new concept, improvements in quality have already been proven. The purpose of the case study performed by Olson and Villeius [13] is to provide another Swedish automotive actor with recommendations in how to ensure that their assembly workers follow standardized assembly instructions. This shows how diverse the current situation in Sweden is today.

Both the case study [13] and the interviews are only performed with engineers. In a deeper analysis all affected and involved roles in the organization should be included in the reflections to give an honest and correct description of the current situation of standardized work in Sweden.

One question that Liker and Meier [1] reflect over is that companies may look like they have implemented lean manufacturing, but how good is the implementation and how good are the actions related to such implementations followed?

The degree of continuous improvements in everyday business should also be discussed. How well are actions related to the work with continuous improvements performed? Continuous improvements are important to keep up a good standard in everyday business. Without good standards and processes of auditing our daily work, how can we know that we are doing the right things?

Car manufacturers are often characterized by using short cycle times, which means short assembly actions and a smaller amount of actions on a single assembly station. If you compare that with a truck manufacturer which uses longer cycle times giving room for more assembly actions on a single assembly station, you have a totally different level of complexity on how to handle the assembly.

Truck manufacturers are facing the complexity of having their products more or less customized for their customer. Using standardized work puts a heavier workload on handle standardized work in the right way.

As mentioned earlier, there are features that should be reflected before beginning with standardization. One of the more critical features is that assembly work should be of a repeatable manner. The question then arises whether truck manufacturing can be standardized? The answer is yes, the manufacturing of a truck can be standardized as it appears that two of the actors reflected
in this paper are truck manufacturers. One of the truck manufacturers has been working with standardized work for quite some time, and the other truck manufacturer is in the starting field of implementing standardized work in the organization.

How modular is a truck when it is seen as a customized product? It always depends on which depth of the product you are analyzing. Even if the customized product itself compared to another product looks totally different, there is more commonality between the products than you might think. This is of course related to the amount of modularity in the product itself. Standardized work on customized products put higher needs of modularity in the product.

Quality at truck manufacturers tends to differ depending on where the production is placed and the question is how much the relation between local best practice and cultural and geographical differences affects the quality? In the future it would be interested to investigate how different work climates related to local developed processes could affect the result in final assembly within automotive industry.

A lot of standardized work today is based on binder systems and sheets of paper. The trends within manufacturing tend to go to more IT supported manufacturing systems such as MES, Manufacturing Execution System. An IT environment might put higher complexity on how to proceed with standardized work; how to handle continuous improvements in everyday business. Processes that are hard to follow or time consuming to follow might not be followed. The role of standardized work in an IT environment is today not clear.

5. Conclusions and future work

This paper gives an insight in the state of the art in standardized work. It defines positive effects of using standardized work but also defines prerequisites being able to effectively implement standardize work in the organization.

This paper also gives the current situation about standardized work in the automotive industry in Sweden. It is here very clear that the concept of implementation of standardized work differs between actors. More work should be performed of evaluating the present concepts of standardized work, to see how they could be integrated in more IT based manufacturing systems.

Today, most research is based on local assembly plants. More future focus should be put in how to implement standardized work in the entire organization capturing cultural and geographical differences and similarities and optimize each actor being number one in each region.

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References

[1] Liker, J. K. and Meier, D., 2006. The Toyota Way Fieldbook - A Practical Guide for Implementing Toyota's 4Ps, New York: The McGraw-Hill Companies, Inc. New York, NY, USA.
[2] Imai, M., 1986. KAIZEN- Att med kontinuerliga, stegvisa förbättringar höja produktiviteten och öka konkurrenskraften, vol. 1:2, G. K. Fredriksson, Ed. Konsultförlaget AB. Uppsala, Sweden.
[3] Frederick, T. W., 1967. The Principles of Scientific Management. W. W. Norton & Company. New York, NY, USA.
[4] Mintzberg, H., 1989. Mintzberg on management. The Free Press. New York, NY, USA.
[5] MacInnes, R. L., 2002. The Lean Enterprise Memory Jogger, 1st ed. GOAL/QPC. Salem, NH.
[6] Dennis, P. and Shook, J., 2007. Lean Production Simplified, 2nd ed. Productivity Press. New York, NY, USA.
[7] Pine, II B. J., Victor B. and Boynton, A. C., 1993. Making Mass Customization Work, in “Markets of One”. Harvard Business School Press. Boston, MA, USA, pp. 149-166.
[8] Hart, C. W. L., 1995. Mass customization: conceptual underpinnings, opportunities and limits, International Journal of Service Industry Management, 6 (2), pp. 36-45.
[9] Pollard, D., Chuo, S. and Lee, B., 2008. Strategies For Mass Customization. Journal of Business & Economics Research, 6(7), pp. 77-86.
[10] Nambiar, A. N., 2009. Mass Customization: Where do we go from here?, in “Proceedings of the World Congress on Engineering 2009”; London, England.
[11] Ericsson, A. and Ericson, G., 1999. Controlling Design Variants: Modular Product Platforms. Society of Manufacturing Engineers. Dearborn, MI, USA.
[12] Pandremenos, I., Paralikas, J., Salomonis, K. and Chryssochou, G., 2009. Modularity concepts for the automotive industry: A critical review. CIRP Journal of Manufacturing Science and Technology, 1 (3), pp. 148-152.
[13] Olson, M. and Villeius, E., 2011. Increased usage of standardized work instructions - Development of recommendations for Autoliv Sweden AB. Department of Product and Production Development, Chalmers University of Technology, Göteborg, Sweden.

1 Read more about MES at the website of Manufacturing Enterprise Solutions Association: http://mesa.org