WORK STANDARDIZATION AND WASTE REDUCTION IN AUTOMOBILE EXHAUSTS MANUFACTURING

Ruslana Hubková (Chomenko) – Felipe Martinez

Abstract

The paper presents the implementation of several Lean Six Sigma tools in the manufacturing process of automobile exhausts. The principal purpose of this paper is to determine the required work standardisation and to improve the production process by eliminating the identified waste. The paper illustrates the creation of individual work standardisation documents for final welding and assembling of the car exhausts. The paper implements project management framework from Six Sigma (DMAIC). The research finds that the production line lacks formal workflow. This standards absence increases process variability and lead-time. The team member work balance chart implementation illustrates bottlenecks at the activities related with three out of the five operators among the three out of the five production line stations. This paper contributes to the creation of the first version of documents of work standardisation. The adoption of these standards reduces process variability. The new team member work balance chart offers a balanced result, which removes the detected bottlenecks. The paper presents the development of a specific process improvement project. Furthermore, the lack of flexibility of the production line layout and budget restrictions reduces the possibility to propose significant changes with other technologies.

Key words: Lean Six Sigma, Work Standardisation, Manufacturing, DMAIC, Car Exhausts.

JEL Code: M10, M11 and M19

Introduction

This paper shows the development of work standardisation using the Lean Six Sigma approach and DMAIC methodology. It investigates the final welding line of automobile exhausts. Five operators serve this production line. However, they follow spoken work instructions from their first working day. These instructions lack any form of standardisation for the operators' work. For years, the line has acceptable parameters. Nevertheless, the organisation notices inconstancy in the process cycle time and several bottlenecks with a negative impact on the production system.

Therefore, this paper aims to determine the influence of work standardisation in this production process. The examination of the theoretical knowledge argues that the introduction of work standardisation and its documentation for operators have a high impact on the manufacturing process and they speed up the overall production. Although, literature presents cases; management needs to be convinced about standardisation benefits. Then, it is necessary to develop more evidence to enhance the current knowledge and bring specific situations for practitioners learning.

1 Lean Six Sigma and Work Standardisation

The Lean methodology facilitates the simplification of processes by reducing waste (Womack & Jones, 1996). Six Sigma reduces defects using statistical methods (Noori & Latifi, 2018). The combination of these two methodologies results in faster and more efficient problem solving and process improvement (Muraliraj, Zailani, Kuppusamy, & Santha, 2018). Lean speeds up Six Sigma, and together they can produce better results. The combination of Lean and Six Sigma creates a comprehensive DMAIC-based tool that can build a more efficient and cost-effective process (Košturiak & Frolík, 2006).

Companies often employ new employees, but they lack a system to train them. This approach to the new workforce creates unnecessary staff failure, time waste, material and costs. The creation and use of standardised work documents help to avoid these failures (Miller, 2011).

Standardisation moderates the relationship between creativity, team performance, and customer satisfaction (Gilson, Mathieu, Shalley, & Ruddy, 2005). The standardisation of work serves as a key factor for industrial evolution (Džubáková & Kopták, 2017). Taylor observes a job and breaks it down into individual tasks (Taylor, 1967).

The work standardisation simplifies and streams processes. Additionally, it removes variability. Furthermore, documentation serves for process effectiveness. Creating standardised workloads ensures a consistently high level of quality, helps maintain production speed and facilitates the implementation of a continuous improvement strategy. Implementation standardisation takes place especially when it is necessary to increase the level of quality and stabilisation of the process and the product, to reduce the bottlenecks and costs of poor quality. Additionally, it increases customer satisfaction (Košturiak & Frolík, 2006).

The standardisation of work operations must follow the best possible order of the process and the most efficient use of materials, machines, etc. including product quality and employee safety. Work standardisation, best practices and waste reduction initiatives do not restrict creativity and flexibility; in fact, it is the opposite (Sayer & Williams, 2012).

Then, without standardisation, despite all the improvements, the improved process will disappear over time.

2 Methodology

The research methodology implements DMAIC cycle from Lean Six Sigma to eliminate errors and to improve efficiency (Karout & Awasthi, 2017).

The project starts with the problem identification phase, i.e. defining the process in detail. This phase contains an explanation using the SIPOC (Suppliers, Inputs, Processes, Outputs and Customer) schema to determine the flow of the manufacturing process from start to finish (Rochman & Agustin, 2017). Layout and flowchart clarify the process. These tools are a graphical representation of successive workflows that serves to display a particular process and shows steps that create or not create value (Damelio, 2011).

Furthermore, Lean Six Sigma determines customers' requirements as Critical to Quality (CTQ). CTQs are the keys quality requirements (Morgan & Brenig-Jones, 2009). All activities in the process must respect standards based on CTQ.

The research also includes video analysis. The video contains the work of each operator. It provides several data for the measurement phase. A Gantt chart compiles the measured data with the sequence of activities. Additionally, the Spaghetti diagram illustrates the operator moves and actions on the shop floor.

The DMAIC phase "Analyse" identifies the most dominant types of waste and their causes. This phase includes brainstorming, Pareto analysis and Ishikawa diagram (Rochman & Agustin, 2017).

The findings from the analysis determine the phase "Improve". The proposed changes focus on the root causes found in the previous phase. The methodology "5 Whys?" also facilitates suggestions for improvement.

The final phase includes the 5W1H tool. It plans the operation to control the changes that allow the improvement of the production process.

3 The welding process

The paper focuses on the welding production lines. It includes the final manufacture of the automobile exhausts and their delivery to the customer. This production line has several operations. A welding robot, which has two doors – "A" and "B" (but now uses just door „B"), a cooling container, several quality control activities, and shipping container. There are five operators on the line, and each of them performs a different job. The first operator works with the welding robot; the other operators check product quality. Each worker controls various aspects of the product differently.

3.1 Process definition

The first tool from DMAIC methodology is the implementation of SIPOC for each of the five operators. Then, layouts facilitate the location of each operator within the process. The process definition also determines the CTQ. In this case, the CTQs are size (the width, length and thickness of the tubes from which the exhaust assembly), time (takt time, cycle time and lead-time), and appearance (any visible signs of damage, such as holes, dents, scratches, purity – means free of residual oil, lubricants etc.).

3.2 Process measurement

The company has a specific technology to store the information from the videos. These data include the product name, the name of lines, machines and the specific takt time (255 seconds).

The data from the videos also provide information about individual steps, walking distances and waiting times. The Gantt chart includes the averages of the measured activities. It illustrates the time intervals of each work activity, waiting, walk, and machine work related to the takt time. The workspace layout with Spaghetti diagram enhances this information. Table 1 shows this information and it reveals that three of five operators have a longer cycle time than the required takt time.

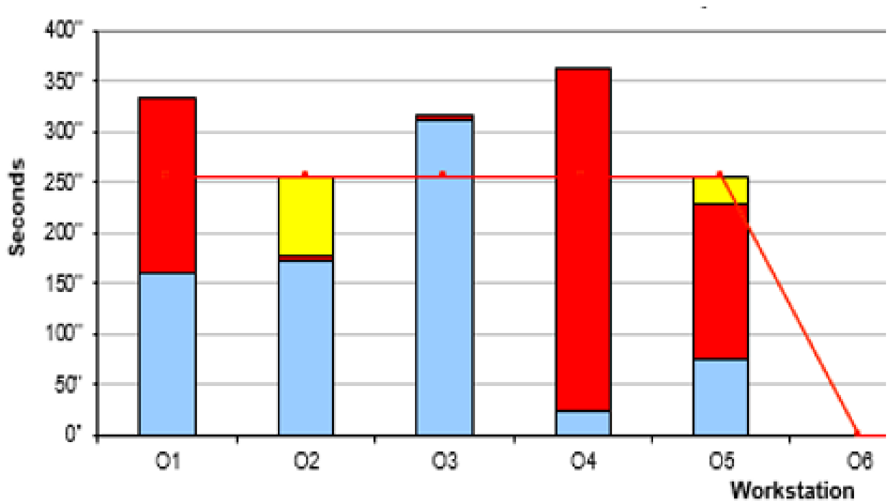
Tab. 1: Measurement results

	Operator 1	Operator 2	Operator 3	Operator 4	Operator 5
Manual work time	153 s	172 s	311 s	21 s	76 s
Cycle time	**334 s**	178 s	**316 s**	**361 s**	230 s
Walking time	11 s	6 s	5 s	3 s	2 s
Waiting time	170 s	-	-	337 s	151 s
Machine time	170 s	-	-	90 s	-

Source: Authors (2018)

The work balance chart compiles information of each process and operator (see Figure 1). It compares the process times of all five operators. The red line represents the requested time. This tool clearly shows three bottlenecks located on the first, third and fourth operators. The balanced process needs that the times of all operators are equal or less than the required time.

Fig. 1: Work balance chart



Source: Authors (2018)

The blue colour in the columns indicates the manual work of the operators; the yellow one illustrates the difference between takt time and cycle time (respectively "reserve" time). The most critical time is the red colour. It represents the proportion between walking and waiting of the operator in the process. These activities do not add value to the customer.

3.3 Process analysis

The collected data evidence three operations out of the required time. The brainstorming technique facilitates the determination of causes. The Ishikawa diagram illustrates six critical causes out of the eightcauses are critical. Moreover, the Pareto's analysis shows the most severe causes.

The first bottleneck presents four potential causes of waste. The highest value (54 points) is the lack of standardisation of work (including the absence of work standardisation documents). Other causes include the difficult handling of material with value 45 points and the long walk. The inappropriate layout is the last cause of this analysis with 40 points.

The second bottleneck also shows that the highest value has the missing documentation of work standards (54 points). The next cause is the potential fact that the operator is slow (45 points) and the job is out of the set time. Another possibility is the variability of work from the operator (38 points).

The causes related to the underperformance of the fourth operator (the third bottleneck) lie in the long wait time from the third operator when controlling the quality of the exhaust.

3.4 Process improving

The suggestion for improvement is the creation of standard work documents for all operators of the entire manufacturing line to avoid further potential losses. The work standardisation document serves as a guide for current and new operators at this workplace. The operator reads the Gantt chart. It includes the sequence of activities and the time duration based on the required takt time. Additionally, the documentation includes the Spaghetti diagram of the workplace with the number of steps to reach the required objects or tools. Furthermore, the standard work document serves management interested in the length of the work cycle and machine run, for example, to find further improvements.

The next suggestion includes the purchase of a special wheeled cart to facilitate material machine loading for a maximum of two production cycles. The wheeled cart requires the handling of all material, and it has easy manipulation. Other production lines use a similar device. This wheeled cart reduces waiting time by a few seconds, but it reduces the total cycle time of the operation. The operator brings the input material just once at the same time when the machine is welding the exhaust. Therefore, it reduces the time for the manual work, walking and waiting.

The third operator requires proper training for the standard work. The activity of control requires efficiency but also time coordination to avoid a lead-time increase. A quality department employee develops the training to communicate the exact activities to ensure products' quality for the final customer.

The work balance chart (see Figure 1) shows that the fourth operator has the highest values out of the required takt time. Moreover, dependability from the other operators creates this long time. The fourth operator has these measurements because the previous operator runs late. Then, the solution is to improve lead-time of operator three. The increase in speed in the third operator makes deliveries of product to the fourth operator more frequent. Then, it reduces wait times of the fourth operator. Furthermore, the fourth operator takes the exhaust from the control activity as soon as it is released to avoid unnecessary delay due to exhaust manipulation.

3.5 Process control

The implementation of the document for work standardisation and the material handling wheeled cart improves the work for the first operator. The work standardisation for the third operator includes the training. This activity also shows improvements. The improvements at the third operator derive into the improvements for the fourth operator. The 5W1H tool creates a plan to review the implemented proposals to the manufacturing process.

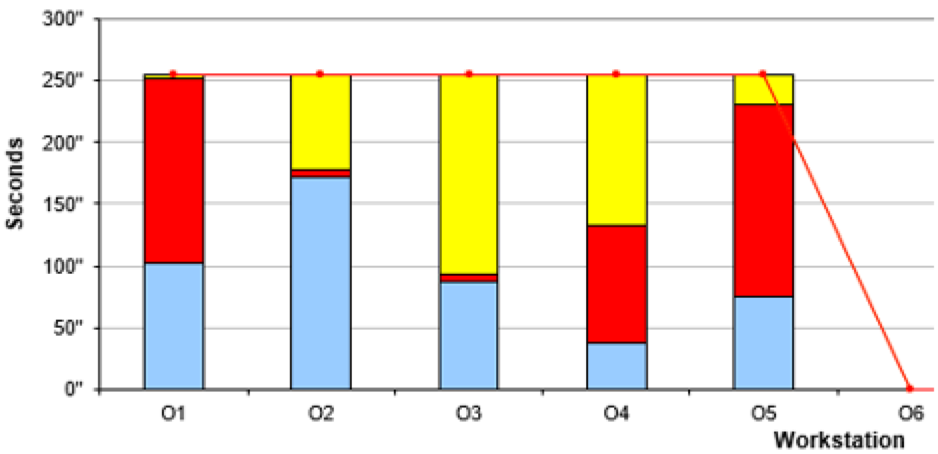
Tab. 2: New measurement results

	Operator 1	Operator 3	Operator 4
Manual work time	103 s	88 s	37 s
Cycle time	**255 s**	**94 s**	**133 s**
Walking time	6 s	6 s	6 s
Waiting time	143 s	-	90 s
Machine time	170 s	-	90 s

Source: Authors (2018)

The new proposed standard work documents and the new work balance chart include the new data (see Table 2). All cycle times are now in line with the required takt time. This means that the manufacturing of the exhaust at the final welding line runs smoothly and, in the set takt time. The new work balance chart reveals all activities to the required takt time (see Figure 2).

Fig. 2: New work balance chart



Source: Authors (2018)

Conclusion

The paper aims to determine work standardisation influence on the production process by reducing work variability of the bottlenecks operators at the automobile exhaust mPanufacturing process. It shows the results of the implementation of work standardisation documents, and it demonstrates production processes variability reduction, operation time improvement of all operators, which contributes to the balance of the total process and the smooth flow of production.

The first operator presents inconsistent operation time with the required takt time. The introduction of the standard work document and the special wheeled cart improve this operation by **23.65%**.

The third operator also realises work without any standards. Additionally, the long operations times influences the operation time of the fourth operator. The introduction of the training and the standard work document improves this operation in **71.25%**.

The fourth operator underperformance comes from the other part of the process. The improvements in the process and the introduction of standard work documentation eliminates the waiting time of 247 seconds and the cycle time improves about **63.15%**.

These results illustrate that the introduction of these documents has a positive influence on the manufacturing processes. It is faster, and it has flow. It eliminates variability, leans the process and provides better manufacture process.

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Contact

Bc. Ruslana Hubková (Chomenko)
Faculty of Business Administration
Department of Management
University of Economics, Prague
nám. W. Churchilla 1938/4
130 67 Praha 3 - Žižkov
chor00@vse.cz

Ing. Felipe Martínez, PhD.
Faculty of Business Administration
Department of Management
University of Economics, Prague
nám. W. Churchilla 1938/4
130 67 Praha 3 - Žižkov
felipe.martinez@vse.cz