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APPLICATION OF LEAN AND SIX SIGMA METHODOLOGY IN IMPROVING OF PRODUCTION PROCESSES

Abstract: This paper describes example of LEAN and SIX SIGMA methodology application in order to improve production processes. The aim of the study was to improve the production processes of wire sheaves for electrical installations of cars and agricultural machinery. The main problem was the high production costs and long lead times of technological process in case of the prototypes and sheaves produced in small series. Significant number of manufacturing defects has also been a problem. The analysis carried out in accordance with the methodology DMAIC and SIX SIGMA allowed identification of the main problems and development of solutions. As a result of the work proper solutions has been developed and implemented to streamline the production processes, as well as improve the quality and efficiency of the production system in the studied area.

1. Introduction

Companies operating in today's globalized market are forced to constantly seek for methods of optimization of their activity, leading to a reduction of production costs and increase of the efficiency of equipment. The continuous improvement of production quality in order to meet the demands of customers and to ensure the smooth operation of production lines leading to the timely execution of customer's orders is also important [1].

There are many methods allowing companies to get closer to that goal. Most often mentioned are such methodologies as lean manufacturing, Kaizen, Value Stream Mapping, TQM and SIX SIGMA, mostly focusing on continuous improvement of company's processes and improving the quality of production [2]. Especially SIX SIGMA methodology is often used in the automotive industry. Car manufacturers using this methodology expect the highest quality of components and, consequently, so in consequence SIX SIGMA should be used also by suppliers of components for assembly [4].

This paper presents an attempt to apply the SIX SIGMA methodology to streamline production processes in a plant producing the wire sheaves for the electrical system of cars, construction and agricultural machinery.

2. Description of the problem

The production facility which is the subject of analysis produces a variety of the wire sheaves to the electrical system in vehicles [3]. Most of these are sheaves produced in long series in large quantities. Production processes of that type of sheaves are optimized and profitable. In this part of the production high quality and low number of defects are obtained, which means that the manufacturing processes are properly organized.

The second part of this manufacturer offer are sheaves produced in small series (usually sold in the aftermarket, for car mechanics workshops) or single prototype sheaves. In this part of offer plant does not reach the expected financial results, production lead times are long, there is also a significant number of defects (waste). The aim of the analysis was therefore to identify the sources of problems and to implement the solutions allowing to eliminate or reduce it [3].

Production processes

The main production processes are cutting wires and insulating sleeves into pieces of required length, connecting it accordingly to the assembly scheme, and then installation of sockets and plugs. Final production operations are assembly of additional layers of insulation and waterproofing [3].

The production process of the prototype wire sheaves consists of the following steps:

- Preparation of project documentation (including list of components and wiring diagram)
- Cutting of wires into pieces of required length
- Cutting of insulating sleeves into pieces of required length
- Arrangement of wires in insulating sleeves according to the scheme
- Assembly of connectors
- Assembly of sockets and plugs
- Assembly of additional insulation layers
- Quality control

A typical order for the prototype sheaves normally includes two pieces of sheaves, a typical small series consists of 5 - 30 pieces, and sheaves for aftermarket are produced in a series of 2 to 10 sheaves. Performance of the analysed prototypes department is about 10% comparing to the series production department.

3. Application of SIX SIGMA in analysis of problems of low quality and performance in the electrical wire sheaves manufacturing processes

In order to solve the problems it was decided to apply the DMAIC model (Define - Measure - Analyse - Improve - Control) used in the SIX SIGMA method [4].

Define

In the problem definition phase SIPOC diagram (Supplier, Input, Process, Output, Customer) has been developed for the analyzed process. The next step in defining the problem is to create a process map based on SIPOC diagram. Process map should show where the potential bottlenecks, faults in the process, and the actions that do not create added value are

located. Then Ishikawa cause and effect diagram (Fig. 1) has been developed, which allows to locate the most important reason of the problems.

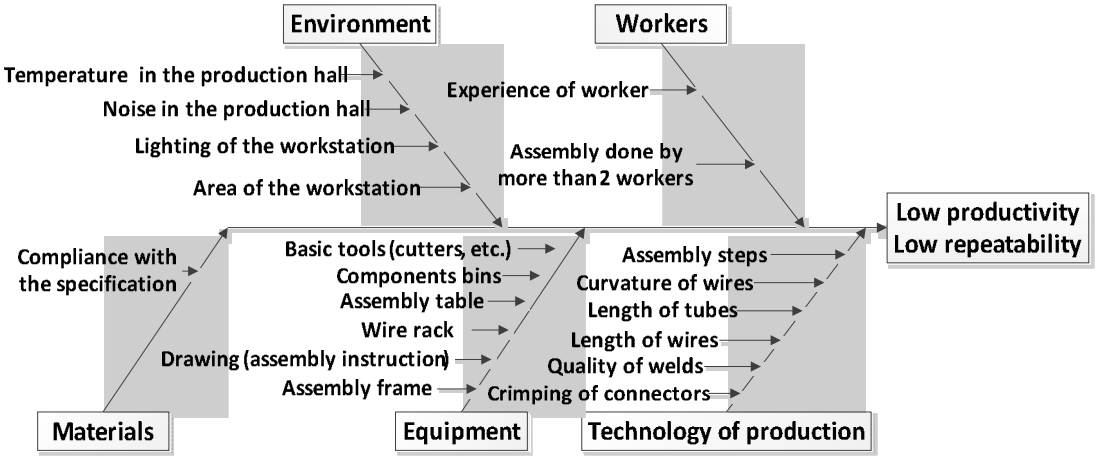

Fig. 1. Ishikawa diagram - simplified

Measure

Measurement of the characteristics of the analysed production processes were carried out on the basis of technological documentation and measurement of the real order execution time. Statistical analysis on the quality of the produced wire sheaves has been also carried-out. For example, the length of the wire ends and compliance with the scheme has been subject of the control. The results of measurements has been processed in the STATISTICA.

Results of statistical analysis of length of exemplar wire are presented on Fig. 2.

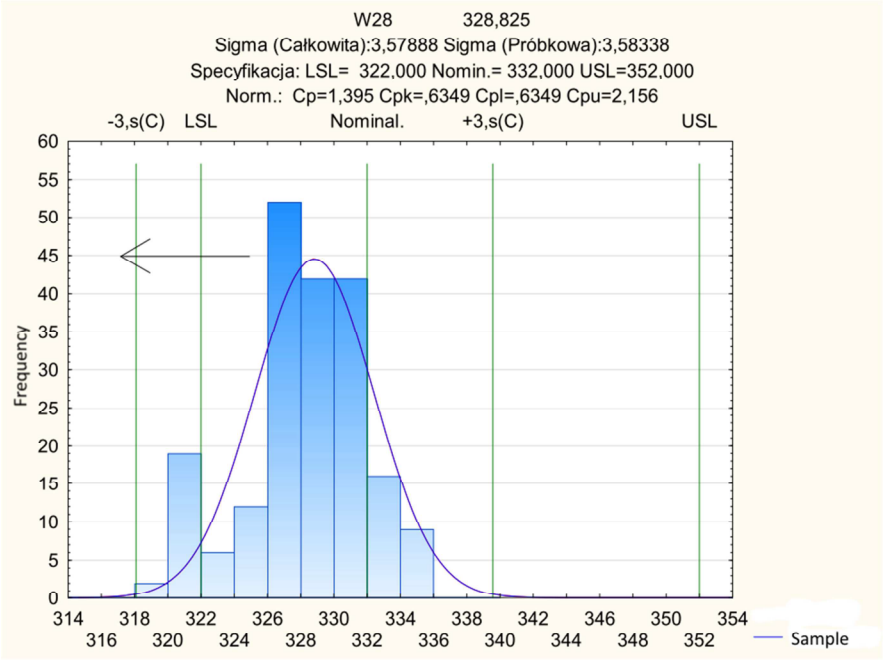

Fig. 2. Results of SIX SIGMA statistical analysis of W28 wire lengthmeasures

Analyse

Analysis of the problem of low (10%) performance was difficult, because not all data were available in the form compatible with the STATISTICA. During the analysis the documentation in the form of photos of the current equipment has been collected.

Current production station for prototype sheaves (Fig. 3) is a universal assembly table, which base is composed of Bosh profile plates. The assembly table currently is not equipped with any brackets (cable holders) for the wire sheaf, which could ensure repeatability of the final product and made assembly easier. Admittedly, table design allows for mounting brackets, but their installation requires the use of additional tools and is long lasting.

Contrary, assembly tables used in mass production (Fig. 4) are equipped with brackets for the wires and hangers for components, located directly within reach of the employee.

Fig. 3. Assembly table for prototype wire sheaves

Fig. 4. Assembly table for middle-series and mass production of wire sheaves

Comparison of the time of assembly of sheaves obtained using a universal table for prototyping and special table used in the series production indicates that the special equipment significantly reduces assembly time. The use of special equipment, however, is not possible in the production of prototypes and small series due to the high cost of such a solution – mass production assembly table is customized for production of given type of sheaves.

Improve

On the basis of results of the analysis it was decided to implement the following improvements in the production processes:

- The new organizational unit in the Production Preparation Department has been created, which is responsible for the preparation of 1:1 scale CAD assembly drawings before starting production.
- The new universal assembly table has been designed. The table has a layered construction (plywood, polystyrene, perforated steel sheet). The 1:1 CAD drawing can be placed on the surface of the table. It is possible to set easy to use magnetic wire holders for cables or nails, placed in locations marked on the drawing (Fig. 5).

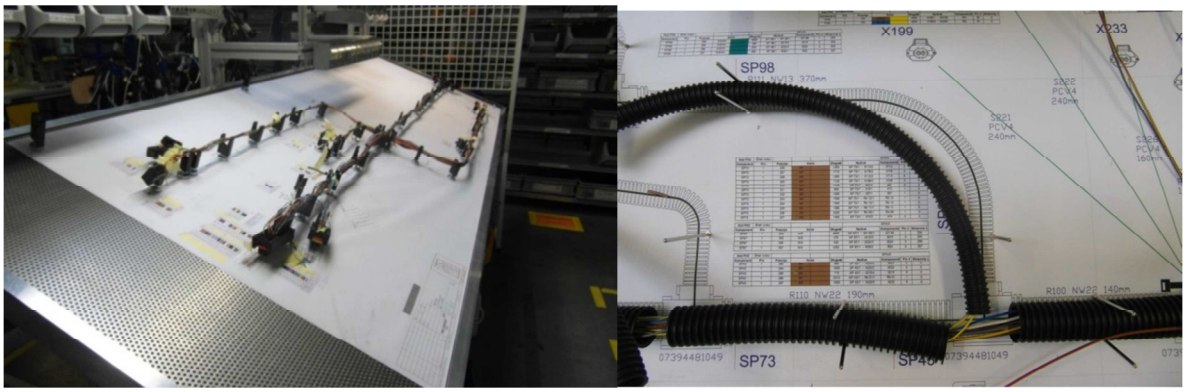

Fig. 5. New universal assembly table with CAD drawing and magnetic cable holders

Control

Control stage consisted of analysing the quality and productivity of the modified production station, measurement of the length of the wires and the control of the performance after the improvements. Statistical analysis (Fig. 6) showed improvement of the quality, the productivity rose from an initial 10% to 30%, which is a good result obtained at a low cost.

4. Conclusion

The case study shows the validity of the application of the SIX SIGMA methodology in order to improve quality and organisation of the production processes. Application of the methodology has allowed to identify the factors responsible for the low productivity and quality of produced prototype wire sheaves, analyse the problem and develop solutions to improve the production processes. Developed solutions have been implemented and tested in practice. As the result satisfactory improvement in the efficiency and quality of the manufactured prototype wire sheaves have been achieved.

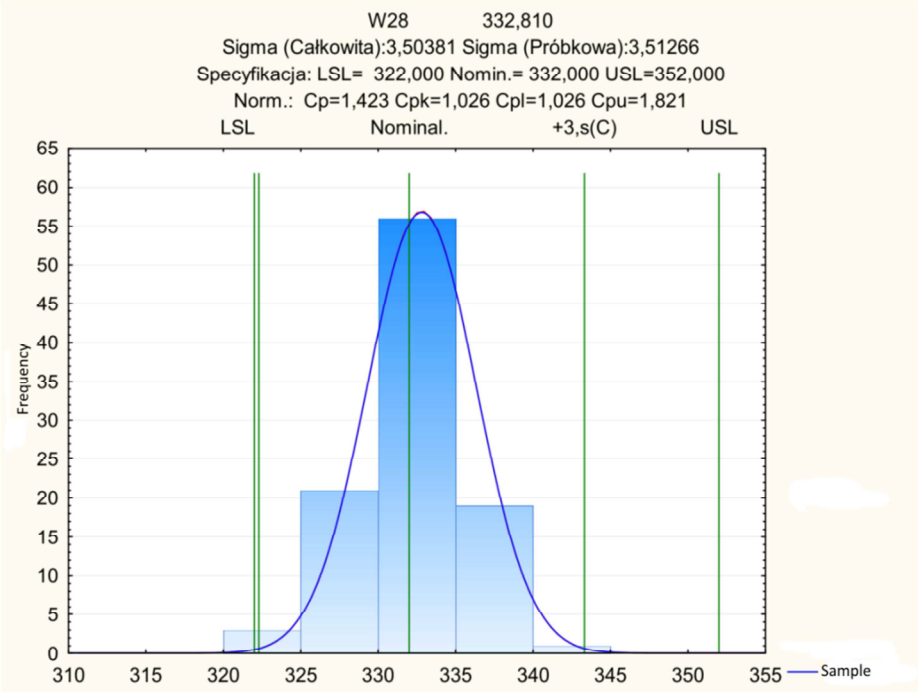

Fig. 6. Results of statistical analysis of W28 wire lengthmeasured after changes

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