IMPLEMENTING A SPC INTEGRATED SYSTEM TO IMPROVE MANUFACTURING PROCESSES IN AUTOMOTIVE INDUSTRY

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Abstract: Nowadays challenges emphasize greatly on the accomplishment of a high level of quality in manufacturing processes, especially in automotive industry. Various methods have been used in order to find ways to organize monitor and control the manufacturing processes. A method used widely to achieve these requirements is statistical process control (SPC). The objective of this study is to present a system which integrates SPC with the results from 3D measuring systems in order to calibrate and monitor manufacturing processes from an automotive industry organization. The implementation of the integrated system has resulted in improvement of the manufacturing processes and, consequently, to a better quality of the final products.

Keywords: *measuring systems, 3D, SPC*

1. Introduction

The challenges in nowadays industry are very strong, the emphasis stressing the need for accomplishing a high level of quality during manufacturing processes. Various methods have been used, especially to find ways to control the manufacturing processes. A method used widely is statistical process control (SPC). Statistical process control is recognized as a technique to achieve cost-effective quality control through continuous manufacturing process improvement [1]. Statistical Process Control (SPC) is a statistical based approach able to determine whether a process is stable or not by discriminating between the presence of common cause variation and assignable cause variation. It is a well-established technique, which has shown to be effective in manufacturing processes.[2]

It is impractical to inspect quality into a product; the product must be built right the first time. The manufacturing process must therefore be stable or repeatable and capable of operating with little variability around the target or nominal dimension. Online statistical process control is a powerful tool for achieving process stability and improving capability through the reduction of variability.[3]

The statistical process control use different devices and instruments for initial acquisition of data. The evolution of SPC can be seen by the large number of specialised hardware and software. In its earlier time SPC means only data analysis from manufacturing processes, today SPC means informatic systems with complex analysis functions, decisions and management. [4].

A widely used SPC system configuration is shown in figure 1.

SPC systems have been the central point of interest in various researches and have known different approaches according to the specific objectives of each study. Following we present some of these approaches.

- Systems that use previous collected data to improve the quality of the manufacturing systems. In one of the studies adopting this approach [5] the authors developed a framework that makes use of self-learning algorithms that enable the manufacturing system to learn from previous data and results in eliminating the errors and consistently producing quality products. The framework relies on knowledge discovery methods such as data mining encapsulated in a process analyzer to derive rules for corrective measures to control the manufacturing process.

- Analysis of statistical instruments used in SPC, such as control charts with the objective of identifying the real time of the process change. [6]. The study presented a method based on the concepts of fuzzy clustering and statistical methods and developed a novel hybrid approach which is able to effectively estimate change-points in processes with either fixed or variable sample size. The proposed approach can be employed for processes with either normal or non-normal distributions. Also, it can estimate the true values of both in- and out-of-control states' parameters.
- Decision support system used to make decisions after analyzing statistical data from SPC [7]. There is presented an advisory decision support system. This system helps in collecting statistical data and thereafter analyzes the enormous volume of data and aids in making quality related decisions. Unlike the conventional SPC applications where the analyzed results have to be interpreted by quality control specialists, Manufacturing execution system (MES) based unmanned manufacturing environments require automation of the interpretation process. The developed advisory system helps in selecting and designing control charts based on various cost, rule or heuristics models. The system also provides interpretation expertise by configuring and applying various rule sets. On violation of these rules, signals are generated by the system and the expert system advices for appropriate remedial actions. Thus the system acts as an advisory support system.
- Analysis of production system architecture which use SPC systems and techniques. The authors [8] presented a new analytical method for evaluating the performance of production systems in which statistical process control (SPC) techniques are implemented. Machines' behaviour is monitored by measuring quality characteristics of the produced parts through off-line inspection devices and sampling inspections. The numerical results show the good accuracy of the proposed method, provide new insight in the relations among the two areas and pave the way to the joint design of production logistics and quality control systems.

In concordance with the recent researches regarding SPC used in manufacturing, the objective of this study is to present a system which integrates SPC with the results from 3D measuring systems in order to calibrate and monitor manufacturing processes from an automotive industry organization.

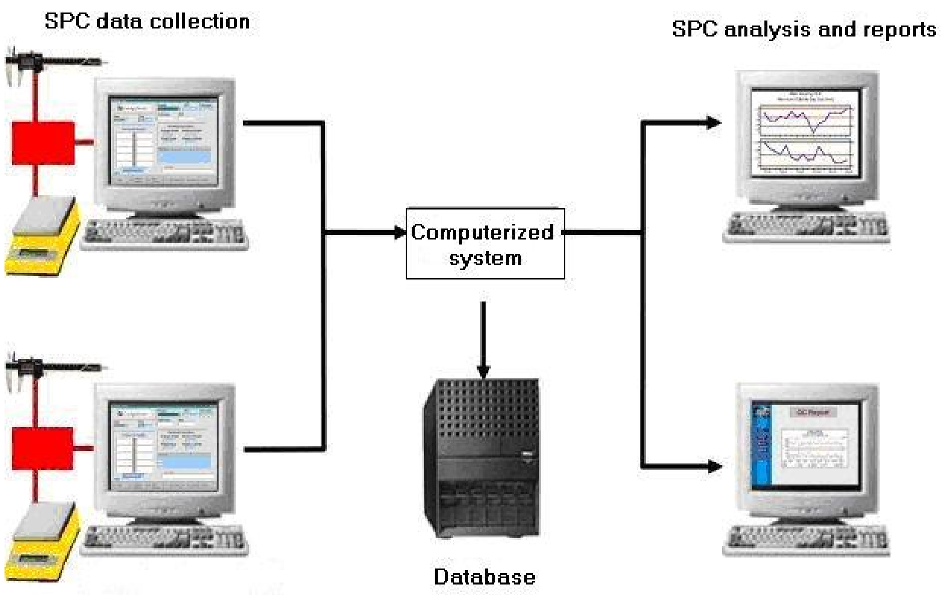

Figure 1: *Generic SPC system.*

2. System development

2.1. Requirements

The development of the system started from a set of specific requirements:

- monitoring workstations in order to rapidly take action when the process is out of limits;
- validation of settings following the change of part, tools or if the process is out of control limits;
- statistical sampling of products key features which cannot be directly monitored at the workstation because of the complexity of the measuring device;
- setting and monitoring of a large number of workstations that otherwise would have needed a numerous and sophisticated measurement devices;
- reduction of cost related to calibration and maintenance of a large number of measurement devices.

2.2. Procedures

The design and development of the system is based on a series of quality procedures developed within the organization. Such procedures are: the procedure for process statistical analysis (fig. 2), process monitoring, process validation, process control through SPC, etc.

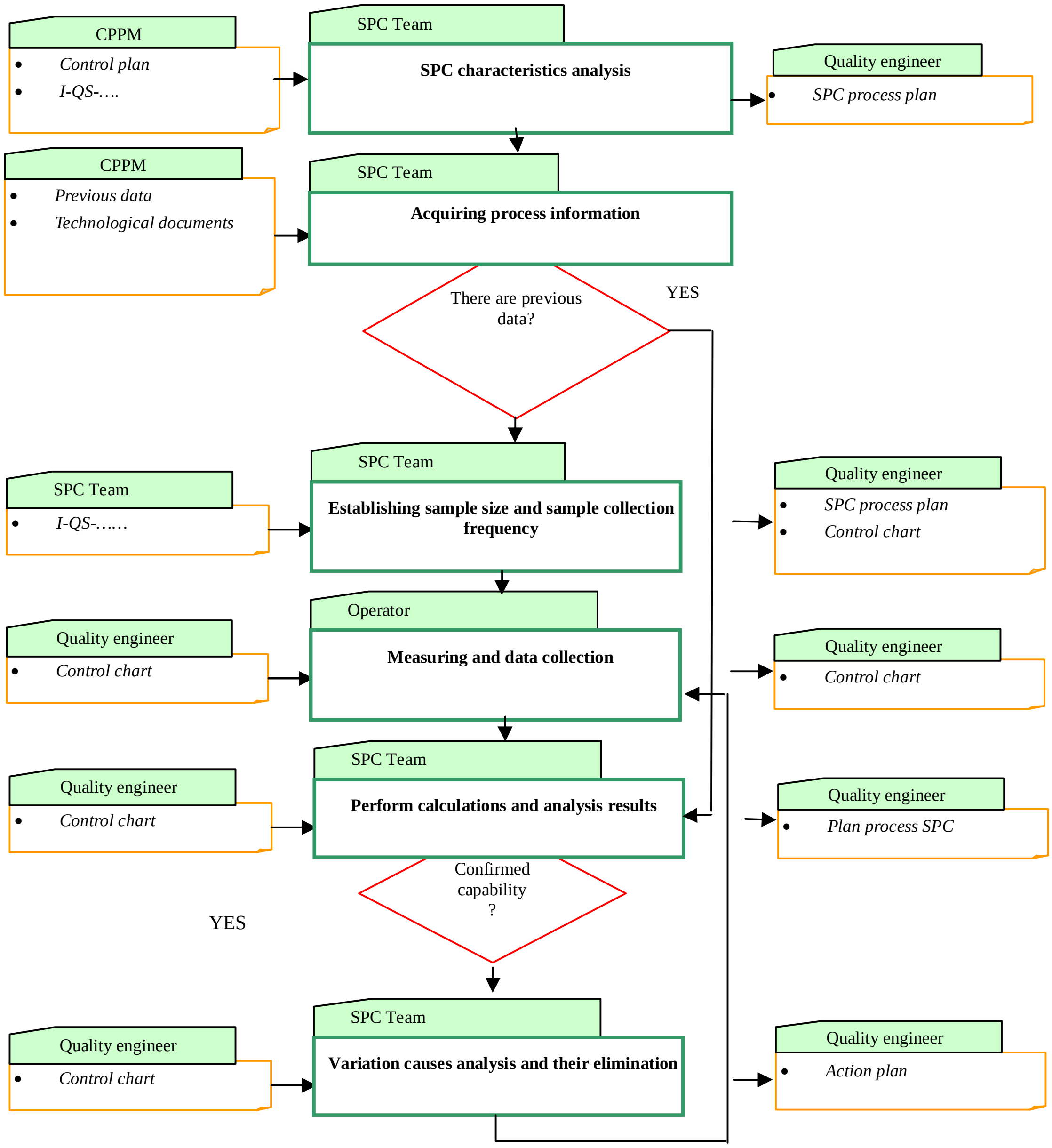

Figure 2: *SPC procedure.*

2.3. SPC conceptual framework system

The SPC system framework (fig. 3) was developed after analyzing the requirements and the procedures. The system is composed of four main elements: 1. the workstations – where the information comes from; 2. coordinate 3D measuring system; 3. the monitoring room – where the process parameters are assessed and visualized; 4. SPC system which integrates the information and transmits the results to available displays for validation and monitoring in the workstations area and the monitoring room.

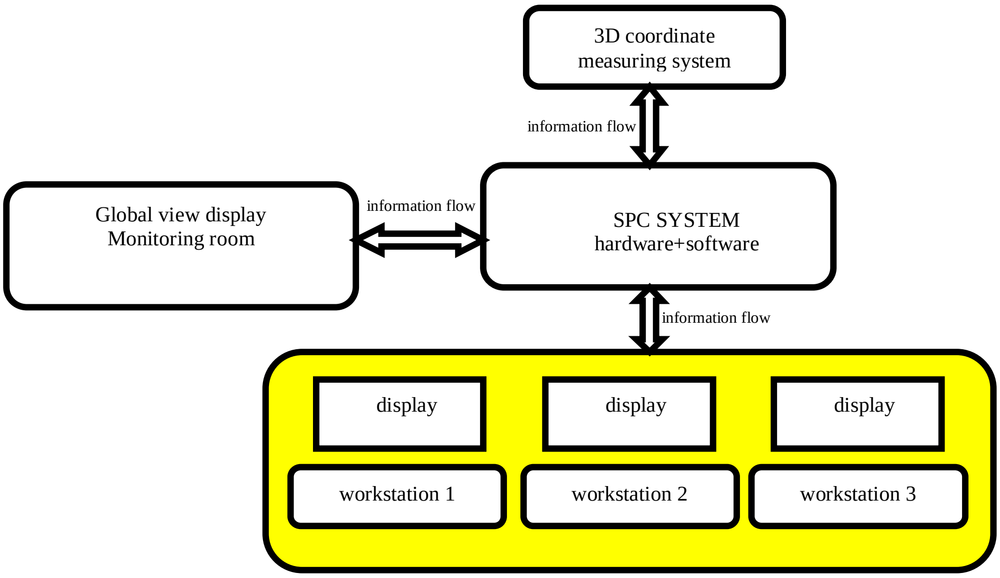

Figure 3: *Conceptual structure of integrated SPC system.*

2.4. System realization

The real system has two main components: the hardware – all the physical equipments that form the SPC system and the software – which comprises the SPC analysis and monitoring application and ensures the information transfer within the system. A detailed presentation of these components follows:

- **The hardware**

Coordinate 3D measuring system (fig. 4). It is used for complex and precise measurements of the collected samples from the workstations.

Figure 4: *3D coordinate measuring system.*

Computers, displays, transferring data systems etc. (fig. 5). All these components are used for data collection, analysis, transfer and visualisation. They assure the correct flow of information and are positioned near the workstations, the measuring systems and the monitoring room.

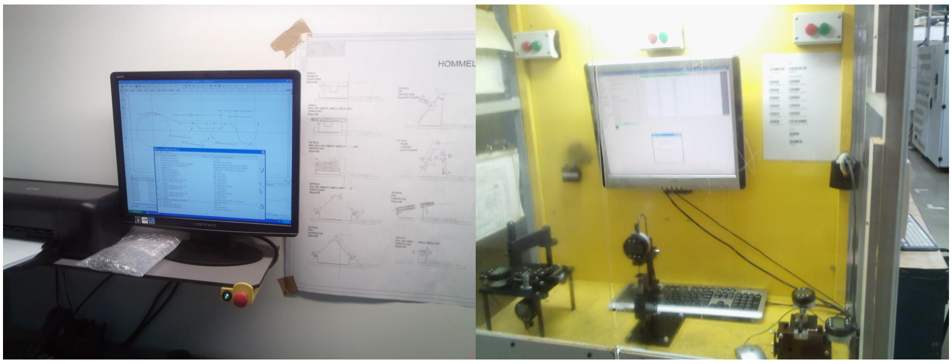

Figure 5: *Components of the SPC system.*

- **The software**

1. The SPC analysis and monitoring application is developed and implemented within the organization allowing:

a) for SPC system:

-data collection from measuring devices;

-data processing and calculation;

-generation of specific SPC graphical and numerical reports (fig. 6);

-process capability study;

-export of reports data;

b) for monitoring (fig. 7):

-support for generating organization layout;

-establishing the connections between system elements;

-real time graphical representation of problems encountered in fabrication process.

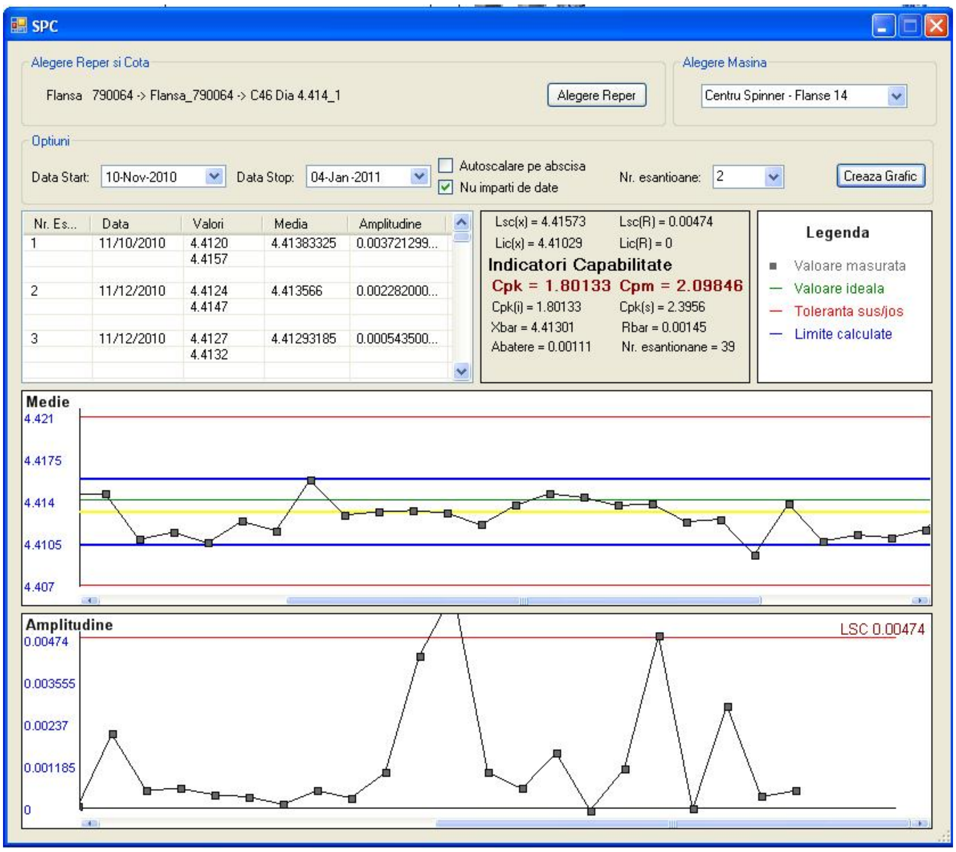

Figure 6: *SPC graphical report.*

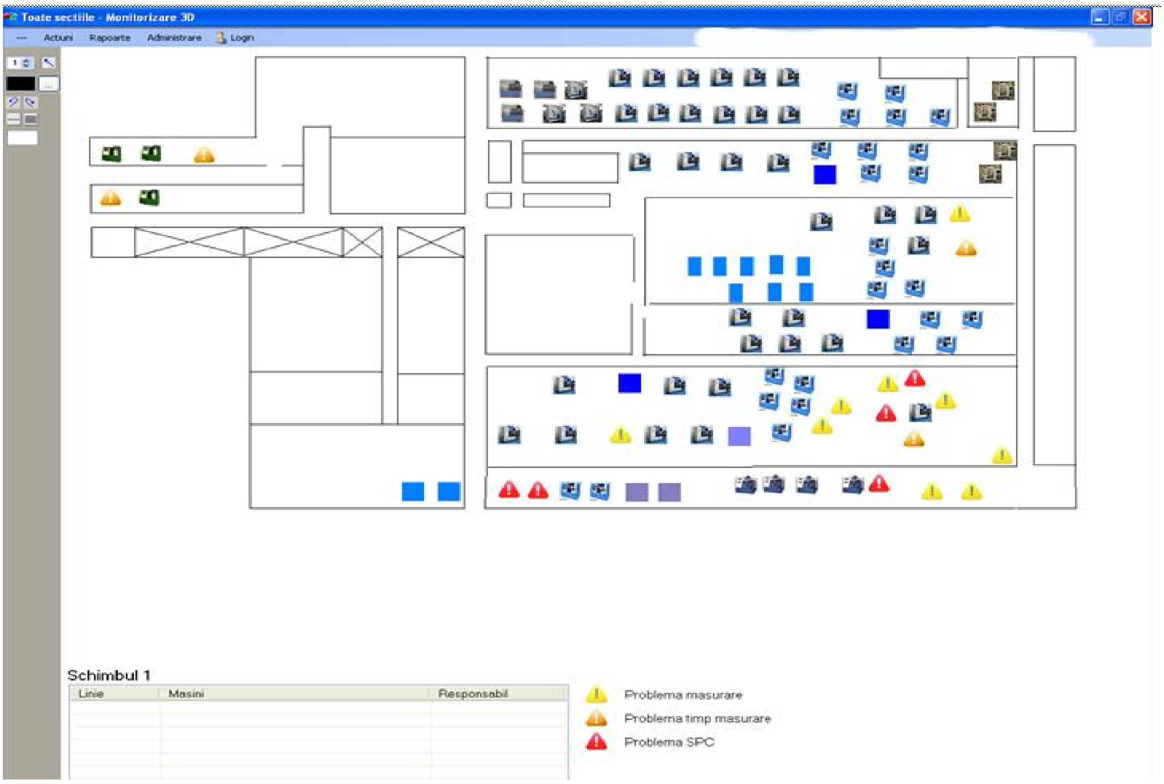

Figure 7: *SPC monitoring layout.*

3. Results following the system's implementation

The system was implemented in an automotive industry organization and has been functional for two years. The results obtained in this period of time are reflected in several areas:

- -the reduction of time with 5%-10% for preliminary and ongoing settings required for the manufacturing processes;
- -ppm reduction with 5%-20%;
- -other costs reduction 1,5%-3% (example: costs related to calibration and maintenance of a large number of measurement devices);
- -raising the awareness of the workers about the functioning of the entire manufacturing system and their role as a part of it;

4. Conclusions

This study has presented a system which integrates SPC with the results from 3D measuring systems in order to calibrate and monitor manufacturing processes from an automotive industry organization. The development of the system had followed certain steps. First there were identified the specific requirements in the organization where the system was created. Then, the design and development of the system followed a series of quality procedures developed within the organization. The next step was to conceptualize a framework for integrating the main components of the system. Based on this framework the physical system was developed combining hardware and software elements. All the software components were realized within the organization so as to fit best for the purpose intended.

It's important to notice that, although the system was created for an organization from automotive industry, it can also be adjusted with minimum changes for manufacturing processes from other industries.

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