Supervisory Control and Data Acquisition System as a Means of Safety at Work Formation in a Manufacturing Company

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Abstract:

Purpose: The aim of the paper is to present an application of the Supervisory Control and Data Acquisition system (SCADA) in the shaping of occupational safety by raising workers' awareness concerning importance of maintaining high personal safety standards in a manufacturing company.

Approach/Methodology/Design: Shaping work safety covers all activities that increase employee awareness concerning compliance with safety regulations and work practices with particular respect to the rules of conduct in specific situations. This article presents the use of the SCADA system in shaping of the workplace safety. It also underlines its influence on raising employee awareness of the importance of complying with health and safety regulations.

Findings: It can be stated that the safety days screen meets the company's expectations. Moreover, it can be a valuable support in shaping workplace safety and raising employee awareness of safe work. The crucial thing is to carry out a detailed analysis and then choose such a solution that is adequate for the needs of a particular enterprise.

Practical Implications: It is noted that the use of any solution that optimizes processes in the enterprise (including manufacturing processes) and the opportunities that IT tools provide, greatly contributes to the growth of safety. Providing safe working conditions by employers is usually closely linked to the organization's management strategy.

Originality/Value: Currently we can observe the growing use of distributed control and visualization systems (SCADA systems) in the automation of industrial processes.

Keywords: Manufacturing company, safety, shaping safety at work, SCADA system

JEL codes: O14, P42, P51.
Paper type: Research case article.

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1. Introduction

Growing competition and globalization of business markets force companies to focus on their core business (Abdel-Malek, Kullpattaranirun, and Nanthavanij, 2005; Parrod, Thierry, Fargier, and Cavaille, 2007). Nowadays, the main priority and necessity of many companies have been a continuous improvement of production processes, quality of products, reduction of all unnecessary costs, fulfilment of strict requirements imposed by norms and customers and formation of occupational safety (Drozd, Wirkus, and Bielski, 2015). Due to the important role of work safety, which is strictly related to production conditions, companies attach ever more importance to the fact that work performed at work stations is optimized not only in terms of productivity but also in terms of their safety (Kędzia, 2003; Milczarek, 2010).

Technological progress, business process optimization, and new business opportunities contribute to the company's ever-increasing use of enterprise management tools, while increasing safety. The use of modern, advanced technology and systems can bring many benefits to businesses. Today's success depends on the ability to adapt constant changes in the environment. All systems, methods and techniques supporting strategic business areas and their safety, greatly simplify and streamline the way businesses operate.

The aim of the paper is to present an application of SCADA in the shaping of occupational safety by raising workers' awareness concerning importance of maintaining high personal safety standards in a manufacturing company. It also takes into account the benefits of the implemented solution.

2. Shaping Work Safety

Work safety is very important. It is an integral part of business management. Companies wanting to improve working conditions and minimize the likelihood of hazards and accidents at work, generally implement safety management systems (Lis, 2013). Workplace safety includes all activities that involve the use of proven practices, creation of behaviour patterns, awareness of hazards and ways of minimizing dangerous situations. Any threat, dangerous event or accident at work should be treated as source of knowledge used in the further operation of the enterprise (Ejdys, 2010). At the moment, all advances in technology and organization involve improvements in safety that affect rational development of production processes. Many companies are increasingly turning to solutions that increase worker safety, affect employee awareness, improve enterprise operation and safety management (Työturvallisuuslaki, 2017; Heikkilä, Kupila, and Riikonen, 2017).

It is noted that the use of any solution that optimizes processes in the enterprise (including manufacturing processes) and the opportunities that IT tools provide, greatly contributes to the growth of safety. Providing safe working conditions by

employers is usually closely linked to the organization's management strategy (Ejdys, Lulewicz, and Obolewicz, 2008).

3. The SCADA System

Adapting companies to changing market conditions is an extremely difficult and laborious challenge. Modern production processes using modern technologies are increasingly complex. Currently we can observe the growing use of distributed control and visualization systems in the automation of industrial processes (SCADA systems). They are used in many areas of industry and infrastructure, guaranteeing the safety of technological and manufacturing processes.

SCADA systems are automation systems used to monitor the course of technological processes. SCADA system gathers information from individual machines and devices in real time, and then it visualizes. SCADA provides discreet control and supervision of production processes at a high level (Wu, Cheng, and Schulz, 2006]. SCADA is widely used in large and medium-sized systems, so there are many kinds of software SCADA systems (Morsi, El Deeb, and El Zawawi, 2009). Modern SCADA software allows visualizing the state of the manufacturing processes and gives the possibility to control it thoroughly while enhancing safety. SCADA systems have a wide range of functional capabilities that optimize many strategic business functions and safety.

4. Analysis of a Manufacturing Company

The analysed manufacturing company was established in 1997. It currently employs 276 people. The company specializes in the manufacture of tools, products, intermediates and metal components. Production process in the researched company is mechanized and automated. Modern machines and equipment in the form of integrated production lines are a strong backbone of the enterprise. The products offered by the company are of high quality and durability. The company continually updates and broadens its offer to meet the growing demands of the market and skilfully adapts it to the needs of its customers. Due to modern machinery park the company is also able to produce metal parts. The quality of the manufactured products is confirmed by the company's quality certificate ISO 9001:2015. The company has implemented the Occupational Health and Safety Management System according to OHSAS 18001:2007, which forms part of the overall management system of the company. In addition, the company has an Environmental Management System according to PN-EN ISO 14001.

5. Limitations and Challenges

The researched company, in order to stay competitive in the market, has greatly modernized many of its functional areas over the last few years. Among other things, it has purchased modern machinery and equipment, extending the capabilities

of its machinery, increasing the safety of its activities in the area of production. It integrated production lines and optimized their operation and control by implementing advanced IT systems such as Enterprise Resource Planning (ERP), Manufacturing Execution System (MES), Computerized Maintenance Management (CMMS), Advanced Planning and Scheduling (APS), SCADA and Data Acquisition. It implemented tools aiming at continuous improvement such as TPM (Total Productive Maintenance), SMED (Single Minute Exchange of Die), 5S and SixSigma. In addition, the company (as it has already been mentioned) has implemented a quality system, Occupational Health and Safety Management System and Environmental Management System. With the implementation of a number of solutions that optimizes the processes taking place in the enterprise (including production processes), in the form of advanced IT systems and tools for continuous improvement, the enterprise (over several years) has become a very modern and competitive company on the market.

Functionality analysis of the company showed a problem that was related to the issue of a board informing about the actual number of days that have passed since the last accident. The board was updated manually – the number of days without an accident was erased manually and then a new number was written on it. The person responsible for updating the board was a member of the Occupational Health and Safety Department. Although the update of the board was to be held daily, the board was not updated at the time of his absence. The company had only one information board, which was available in one place – not every employee had access to the information on it. In addition, the passage of time also left its strong mark on the company's board. Therefore, the information board significantly departed from the current standards in the enterprise. It is important to note that the company puts a great deal of emphasis on occupational safety. The old, destroyed and outdated board made it seem as if safety matters were of marginal importance for the company. The company could no longer afford to lose its reputation. The board had to change its appearance in order to match the company's current safety standards.

Due to the fact that the company wished to have an information board on days without accident, it needed to be adjusted to the company's standards. Therefore, it was necessary to develop a modern solution that would meet the expectations of the company. However, before the proposed solution was developed, the company presented the requirements for the information board to the organization. Firstly, the company wanted the board to be modern and electronic. Secondly, it had to be updated automatically. Finally, information contained in the whiteboard had to be available in multiple locations across the enterprise. The proposed solution was inexpensive and it utilized the company's resources, including the SCADA system.
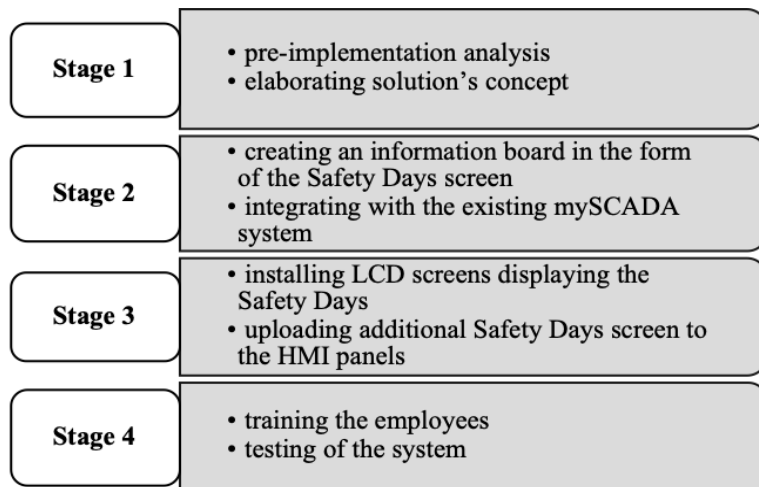
The company's SCADA system had a wide range of functional capabilities that met the company's expectations. It was proposed to create an additional screen (in the company's SCADA system), which would display information on the number of days without an accident - Safety Days screen. Moreover, it was proposed to

integrate the screen with existing HMI panels so that machine operators could get information on the number of days without an accident without having to leave their workstations. In addition, it was proposed that the Safety Days screen would also be available through the company's web browser so that it could be displayed on devices with a web browser (computers, mobile devices, and LCD TVs) connected to the company network. Finally, it was offered to update the date of the last accident via a web browser. The company got acquainted with the proposed solution, analysed the proposal in terms of criteria and decided to implement it.

6. SCADA System: Visual Work Safety Shaping

The main challenge for the company was to efficiently and effectively implement the proposed solution, utilizing the functional capabilities of the SCADA system. The company had its own mySCADA system, which worked under the control of the Linux Debian operating system. mySCADA is available through a web browser (from any PC, tablet, smartphone or even SMART TV). The implementation of the proposed solution in the form of Safety Days screen created in mySCADA system, which displays information on the number of days without accident, was divided into four stages, as shown in Figure 1.

Figure 1. *Stages of the Safety Days screen implementation in the researched company*

Stage 1	• pre-implementation analysis • elaborating solution's concept
Stage 2	• creating an information board in the form of the Safety Days screen • integrating with the existing mySCADA system
Stage 3	• installing LCD screens displaying the Safety Days • uploading additional Safety Days screen to the HMI panels
Stage 4	• training the employees • testing of the system

Source: Own.

Stage 1 of implementing the proposed solution started from pre-implementation analysis, which was an integral part of the implementation itself. Pre-implementation analysis included a detailed specification of requirements that the solution's concept should fulfil. Then the concept of the proposed solution was developed. It covered all the crucial requirements stated by the company concerning the Safety Days screen.

Stage 2 of implementing the proposed solution consisted of creating an information board in the form of the Safety Days screen in the company's mySCADA system. This stage of implementation was very meticulous, because it had to meet the requirements of the company and had to continually present information on the screen. Then, the Safety Days screen was successfully integrated with the existing mySCADA system. Finally, its visualization and software configuration was carried out.

Stage 3 of implementing the proposed solution included installation of LCD screens displaying the Safety Days in the designated locations in the production hall (and elsewhere), and uploading additional Safety Days screen to the HMI panels.

Stage 4 of implementing the proposed solution included employee training and system testing. The main priority and the challenge of Stage 4 was to achieve the intended goal, which was efficient operation of the Safety Days screen.

The implementation of the Safety Days screen in the enterprise took 3 months and was a success. The implementation of the Safety Days screen met the requirements of the company and solved the problem of having an inefficient, manual information board on days without an accident at work. The Safety Days screen provides instant access to the information displayed on it, the flow of information and graphical visualization of safety workflow. At the same time it raises workers' awareness concerning the importance of compliance with health and safety regulations. The information displayed on the Safety Days screen includes an automatic display of the number of days without an accident as well as emergency calls.

An example of a screen shot showing the graphical interface (HMI) of the implemented solution, in the form of the Safety Days screen in mySCADA is shown in Figure 2.

Figure 2. *Stages of the Safety Days screen implementation in the researched company*

Source: *Own.*

The Safety Days screen has been displayed on more than a dozen LCD screens hanged in more than a dozen locations throughout the company. Today the Safety Days screen is situated in the production hall where the information on the screen is visible and accessible to every employee. In addition, the Safety Days screen is displayed (on LCD screens) in the locker room for employees, in the dining area, in the office and at the reception of the company. Access to the displayed information on the Safety Days screen is unlimited because the view of the Safety Days screen is provided by the web browser on the factory network. This ensures that the information contained in the Safety Days screen is displayed on devices that have a web browser (i.e. computers, mobile devices connected to the corporate network).

Thanks to the implementation of the Safety Days screen (created in the company's mySCADA system), the company has acquired a modern board, which in its construction has an automatic non-accident days update and emergency calls. In addition, the Safety Days screen is displayed on LCD monitors in many areas of the company and it is available from many company locations. The Safety Days screen is also available on devices that have access to the company network and the web browser.

7. Quantitative Survey Among Employees of the Analysed Enterprise on the Implemented Safety Days Screen

A short survey among employees of the company was conducted in order to obtain their opinions on the implementation of the Safety Days screen (shown on LCD screens at various locations in the company).

The quantitative survey was conducted using a standardized questionnaire in paper form distributed among a group of workers. The survey questionnaire contained 4 questions (apart from the respondent's particulars), i.e.:

- Is the information displayed on the Safety Days screen readable and understandable for you?
- Is the information displayed on the Safety Days screen useful?
- Does the information displayed on the Safety Days screen raise your awareness concerning the company's health and safety regulations?
- Does the information displayed on the Safety Days screen contribute to work safety?

The survey was anonymous. It was conducted to obtain information on employee safety and employee awareness by displaying information on the Safety Days screen. Respondents were women and men of all ages (from 23 to 60 years old). All people who participated in the study were at least 18 years old. The survey was conducted among 187 respondents. The analysis included 185 questionnaires that were correctly completed, 2 questionnaires were rejected (not analysed) because they were incorrectly filled in.

The first question in the questionnaire asked about the readability of the Safety Days screen and whether the information contained in it was understandable, Figure 3.

Figure 3. *Is the information displayed on the Safety Days screen readable and understandable for you?*
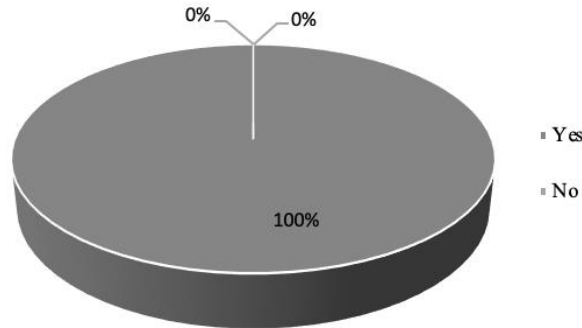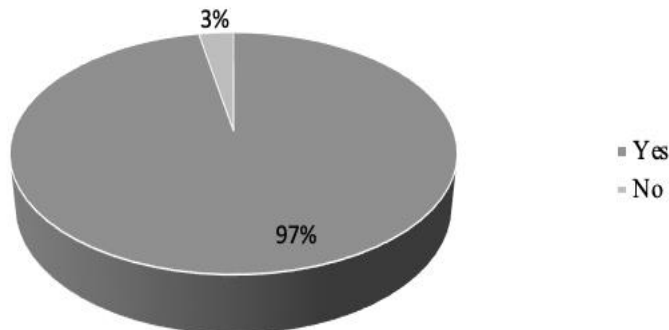

Source: Own.

By analysing the results of the first question in the survey, it was noted that 100% of respondents chose answer "Yes". This indicates that the information displayed on Safety Days screen is readable and understandable for employees.

The second question in the survey concerned the usefulness of the information displayed on the Safety Days screen, Figure 4.

Figure 4. *Is the information displayed on the Safety Days screen useful?*
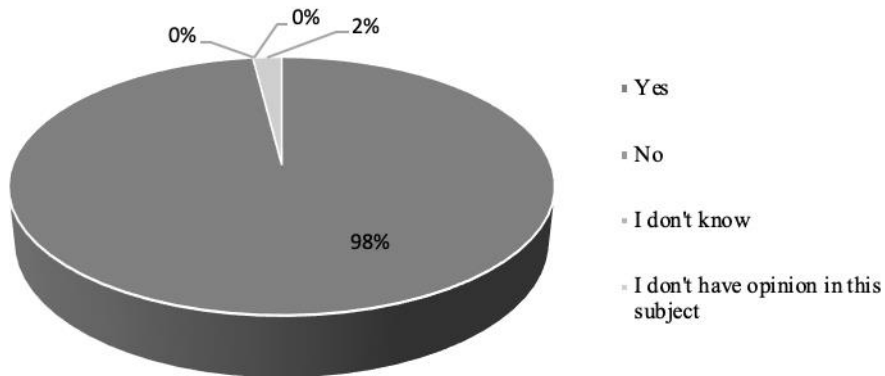

Source: Own.

97% of respondents said "Yes" giving the answer to question number two. Only 3% of respondents chose answer "No". The number of positive responses indicates that the information displayed on the Safety Days screen is useful.

The third question in the questionnaire asked respondents whether the information displayed on the Safety Days screen raises their awareness of the compliance with the company's health and safety regulations, Figure 5.

Figure 5. *Does the information displayed on the Safety Days screen raise your awareness concerning the company's health and safety regulations?*
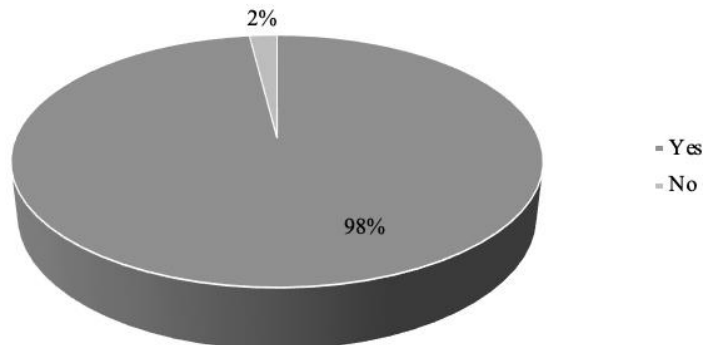

Source: Own.

By analysing the results of the third question, it was noted that 98% of respondents chose the "Yes" answer. Only 2% of respondents chose the answer "I do not think so." None of the respondents chose "No" and "I do not know" answers. Objectively, it can be stated that the results prove that the information displayed on the Safety Days screen raises awareness of compliance with the company's health and safety regulations.

The fourth question in the questionnaire asked whether the information displayed on the Safety Days screen shapes work safety, Figure 6.

Figure 6. *Does the information displayed on the Safety Days screen contribute to work safety?*

Source: Own.

By analysing the results of the fourth question, it was noted that 98% of respondents chose answer "Yes". Only 2% of respondents chose "No". The number of positive responses indicates that the information displayed on the Safety Days screen contributes to safety at work.

In conclusion, the results of the survey prove that the SCADA Safety Days screen raises employees' awareness of compliance with health and safety regulations and contributes to the safety at work in the manufacturing company.

8.   Significant Benefits of SCADA Usage in a Manufacturing Company

Using the Safety Days screen has brought many benefits to the company. The Safety Days screen (in mySCADA system) has streamlined transmission of information on accident-free days, which is available everywhere in the enterprise. By providing a view of the Safety Days screen via web browser of the company network, access to the information contained on the Safety Days screen has become unlimited. The Safety Days screen can be read on computers and mobile devices.

By analysing the results of employee surveys, it can be objectively stated that the implemented Safety Days screening solution has brought benefits for the company because it shapes safety at work by raising workers' awareness of safe work. More than 95% of respondents respond positively to the implemented solution in the form of the Safety Days screen in the company. The vast majority of respondents expressed a positive opinion about the information displayed on the Safety Days screen. As many as 98% of respondents in their responses have confirmed that information on the Safety Days screen increases awareness of compliance with safety regulations and contributes to the safety of work in the enterprise.

In summary, the use of the functional capabilities of the SCADA system, which enabled creating the Safety Days screen indirectly contributed to shaping work safety in the manufacturing company. Thanks to the visual capabilities of the SCADA system, the created Safety Days screen has been a modern, cost-free solution that meets the needs of the enterprise. The Safety Days screen, which replaced the manual information board, has been adapted to the company's occupational safety standards. The Safety Days screen now represents an important element in perceiving a company as an organization that creates an image of a modern and secure enterprise in a competitive market.

9.   Conclusion

The aim of the study was to present the use of the SCADA system in shaping occupational safety by raising employees' awareness concerning the importance of complying with health and safety regulations in the manufacturing company. It also takes into account the benefits of the implemented solution.

The Safety Days screen (created in mySCADA system) informing about the number of days without an accident in the researched company, proved to be the right solution. The company has acquired a modern and available anywhere in the enterprise board, which is displayed on computers, LCD monitors and mobile

devices. In addition, the implemented Safety Days screen has a positive impact on the perception of the company as modern and taking care of its employees' safety.

The results of the survey among the workers of the company on the Safety Days' screening prove that more than 95% of respondents respond positively to the solution implemented. They think that the information displayed on the screens is useful for them and raises their awareness of the compliance with occupational health and safety regulations.

In conclusion it can be stated that the Safety Days screen meets the company's expectations. Moreover, it can be a valuable support in shaping workplace safety and raising employee awareness of safe work. The crucial thing is to carry out a detailed analysis and then choose such a solution that is adequate for the needs of a particular enterprise.

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