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MODERN SUPERVISORY CONTROL SYSTEM IN A PNEUMATIC TRANSPORT SYSTEM: PRACTICAL REALIZATION

MODERAN SISTEM UPRAVLJANJA I NADZORA U SISTEMU PNEUMATSKOG TRANSPORTA: PRAKTIČNA REALIZACIJA

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ABSTRACT

Modern supervisory control systems cover a large number of different solutions for different production processes. A pneumatic transport process of powdered and granular materials served as an example in this paper. The supervisory control system performs a task of controlling and supervising transport paths. The paper presents a possible solution for a supervisory control system and its practical realization. The task of this SCADA (Supervisory Control and Data Acquisition) system is to meet all functional requirements and to offer a user-friendly everyday production system. The practical implementation of SCADA system is based on the underlying programmable logic controller. The solution presented in the paper can be used in similar transport systems in production plants.

Key words*: transport, pneumatic, programmable logic control, SCADA, supervision, practical implementation.*

REZIME

U procesu proizvodnje i skladištenja zrnasto-praškastih materijala kao čest sistem transporta se koristi pneumatski transport. Kao i svi procesi u savremenoj industrijskoj proizvodnji i proces transporta je jedan od zahteva modernog upravljanja i nadzora sistema. Uzimajući ovo u obzir u radu je prikazan jedan takav moderan sistem upravljanja pneumatskim transportom materijala primenom programabilnog logičkog kontrolera i SCADA (Supervisory Control And Data Acquisition) sistema za nadzor i upravljanje. Sistem se sastoji od nekoliko paralelnih linja koje transportuju materijal u veći broj ćelija, a korišćenjem skretnica se odabira odgovarajući transportni put u kombinaciji sa ostalim elementima neophodnim za ispunjenje uslova uspostavljanja transportne putanje. Koristeći programabilni logički kontroler i SCADA sistem realizovano je upravljanje i nadzor sistema. Kontrolno upravljački sistem treba da obezbedi mogućnost odabira transportne putanje kojom će se transportovati materijal. Osim toga, u toku transporta treba da proverava uslove transporta i ispravnost izabrane putanje i u slučaju nepravilnosti da prijavi grešku i zaustavi transport. Upotrebom modernih nadzorno upravljačkih sistema moguće je realizovati sistem koji ostvaruje funkcionalno zadovoljenje postavljenih zahteva ali i pruža jednostavnost svakodnevnog korišćenja i praktične upotrebne primene, te će i sa te strane biti posmatrano i diskutovano rešenje. Predloženo rešenje je praktično implementirano i realizovano na realnom sistemu pri čemu su date smernice praktične realizacije sa osvrtom na mogućnosti korišćenja predstavljenog rešenja u sličnim transportnim sistemima.

Ključne reči: *pneumatski transport, programabilni logički kontroler, SCADA, nadzor, upravljanje, praktična implementacija.*

INTRODUCTION

In processing industry, there is often a need for transporting powdered and granular materials during their production and storage. This is the task of a modern supervisory control system (*Klinzing at al., 2010*). This paper presents such a system realized by using SCADA (Supervisory Control And Data Acquisition) software. The realized system uses all the advantages of modern supervisory control systems (*Bugarski at al., 2011*). Special attention was paid to the presentation of the realized system, the proposed solution and the presented components of the supervisory control system used in practical realization. The use of programmable logic controllers (PLCs) and SCADA systems allowed great flexibility in the implementation of the control systems (*Bailey and Wright, 2003*). The realized system meets functional requirements and it is designed in a user-friendly manner with the possibility of changing the transport path by choosing destination. The supervisory control system consists of two basic components: PLCs and SCADA system which will be described in the following sections. The PLC and its functionality will be described in conjunction with the SCADA system, which is the interface between the process and the human (operator) (*Groover, 2007*). The proposed solution is created to satisfy the system functionality as well as to provide the practical application by observing and making adjustments in order to obtain a user-friendly solution for everyday use. One of the requirements supervisory control systems have to meet is the use of widely accepted solutions in the field of information technology tailored to the specific needs of a given process. The following chapters describe the supervisory control system and its components used in the realization of the transport system and the proposed software solutions.

System description

The transport system consists of multiple parallel lines for transporting materials and the corresponding switches which direct the material into the storage cells (*Bugarski at al., 2010*). In the observed case, each transport line is connected to a production process or corresponding production device. The transmission path should enable the transport of the materials to the appropriate storage cell. The particular system uses air for transporting powdered and granular materials. Supervisory control should enable the management of the path in the system, the detection of the critical levels in the storage cells in conjunction with blowers which provide transport and aspirations of individual storage cells.

Figure 1 shows the technological scheme of the controlled system. There are several parallel lines which originate from different production lines and the layout of switches. The principle of operation is based on setting the switch to the proper position in order to direct materials to the appropriate storage cell. Each switch is equipped with the position detector which allows tracking the position of a switch with the aim of verifying the correct path of transported materials. The position is constantly monitored and if not appropriately placed this will interrupt the transport of the materials. The other conditions necessary for material transport such as the level in the cell or the failure of the aspiration devices are also monitored. All signals are connected to a PLC as standard voltage or current signals or as a part of a distributed system. During the implementation, we use distributed peripheral systems connected to ProfiBus network, whereas the distributed modules of peripheral system are placed near the equipment. A proper choice of place for the modules of peripheral system can reduce wiring need to connected sensors and actuators to a PLC device. This also reduces the time of system implementation and the cost of maintenance during the lifespan of the system. Nowadays, modern control systems often use distributed peripheral systems. From the SCADA viewpoint, there is no difference between centralized and distributed systems, whereas from the viewpoint of connectivity significant savings can be achieved regarding both financial terms and system operating costs. Considering all the above-mentioned facts, it is necessary to connect sensors and actuators in the system by using distributed peripherals.

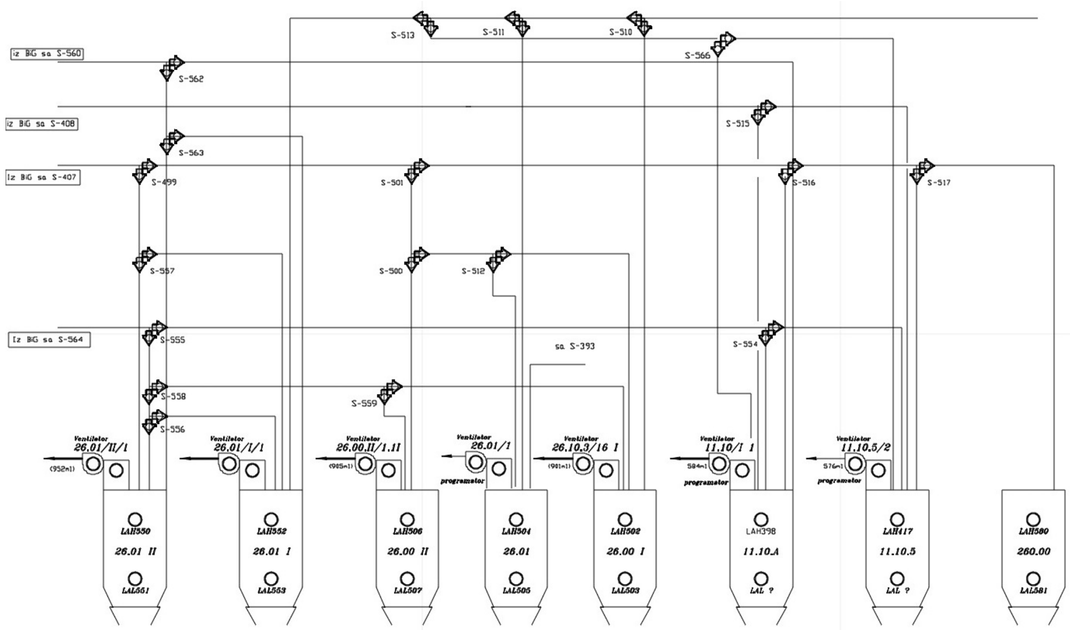

Fig. 1. System schematic

The supervisory control system is devised by using a Siemens PLC series S7-300 equipped with the appropriate number of digital inputs, analogue inputs and output modules as well as communication channels for connecting distributed peripheral modules and the SCADA system. In practice, the distributed peripherals are connected by using the communication protocol ProfiBus and the SCADA system is connected by using the Ethernet communication (*Vasić at al., 2006*). A part of the PLC is used for task management and the transport process supervision. The supervisory SCADA system was implemented by using the WinCC software package which provides a complete graphical representation of the system, the system parameter setting and the acquisition of the collected values. The PLC and the SCADA together make a supervisory control system with the purpose of connecting the man (operator) and the system, thus making a human machine interface. This equipment is necessary to collect data in the process and to realize a supervisory control system which meets system functionality requirements.

RESULTS AND DISCUSSION

The previously described system with the corresponding elements can be used for supervisory control functions. It is possible to implement different solutions for transport route management. With this type of a system, end users can often choose the transport path only by setting the transport elements in a desired position. Our intention was to make a system which can enable end users to choose the desired transport path by setting individual elements in system and also choose the path by selecting the transport route. The solution which meets both requests is the manual choosing of the transport path by using individual transport element and the selection of transport path. The realized system is such that there are predefined transport routes in each of the independent pathways. From the control standpoint, the predefined paths are sets of parameters and signals that need to be provided to make transport possible. For this reason, we considered two possible solutions for keeping predefined paths. Predefined paths are the set of parameters whic must meet transport conditions by using the appropriate line for transport and can be stored in a PLC or SCADA system (*Nikolić at al., 2010*). Considering the two possible solutions, keeping a set of parameters in the SCADA system gives us the ability to modify the parameters because the end user can easy change the parameter set needed to make transport possible. The storage parameters require a proper place or method that can be in the form of a database in case of a large number of parameters, or in some other form if a small number of transport parameters is present. In the case of using the independent SCADA systems for redundancy purpose in the same control system, problems occur with the synchronization between the SCADA systems because they store data locally. It is necessary to provide a mechanism for synchronizing the data (*Ponsa at al., 2010*). In the case of using the database, there are widely used mechanisms for synchronizing data between implemented databases. In other case, parameters can be stored in a PLC and this requires the memory resource reduced flexibility because in this case the end user cannot easily change the set of parameters needed for transport. Such a solution does not require synchronization mechanisms. The variant where necessary conditions for transport are stored in the PLC is used when there is a need for the amount of information and the frequency of changes, like in the presented system. We chose the solution where the transport path is stored in the PLC device. This solution is satisfactory due to technical features which do not allow easy changes in transport routes but simplify the SCADA system and it can be used for specific implementation. For this type of system with a small number of transport paths without the need for frequently changing paths, the solution of storing transport paths in the PLC device is satisfactory.

Usually other similar systems use PLC for storing transport paths like in this practical realization but this method of storing transport paths is good only for small systems with a limited number of transport paths. A big system with more transport paths which are frequently changed by end users requires some kind of database for storing transport path. Our control system has a possibility of controlling the transport path by choosing both the individual elements and the destination.

Figure 2 presents the graphical display of the SCADA system where all the elements of the transport system are visually presented with the possibility of choosing the path of transport. Choosing the path of transport on the SCADA initiates the procedures on PLC that execute procedure set elements in the proper position and check if all elements meet the requirements for a given path. The control system constantly checks the conditions for transport paths and if necessary stops the transport. In the SCADA system, we have a visual representation of all the elements in transport systems. They are presented by their position and have graphical representation of the active transportation route. The proposed supervisory control system provides two modes. The first mode comprises the manual mode adjusting all the system elements manually with a controller checking the conditions and finding appropriate transport path and the SCADA system showing the path where this condition is met. The second mode is a choice of transport paths. In this case the

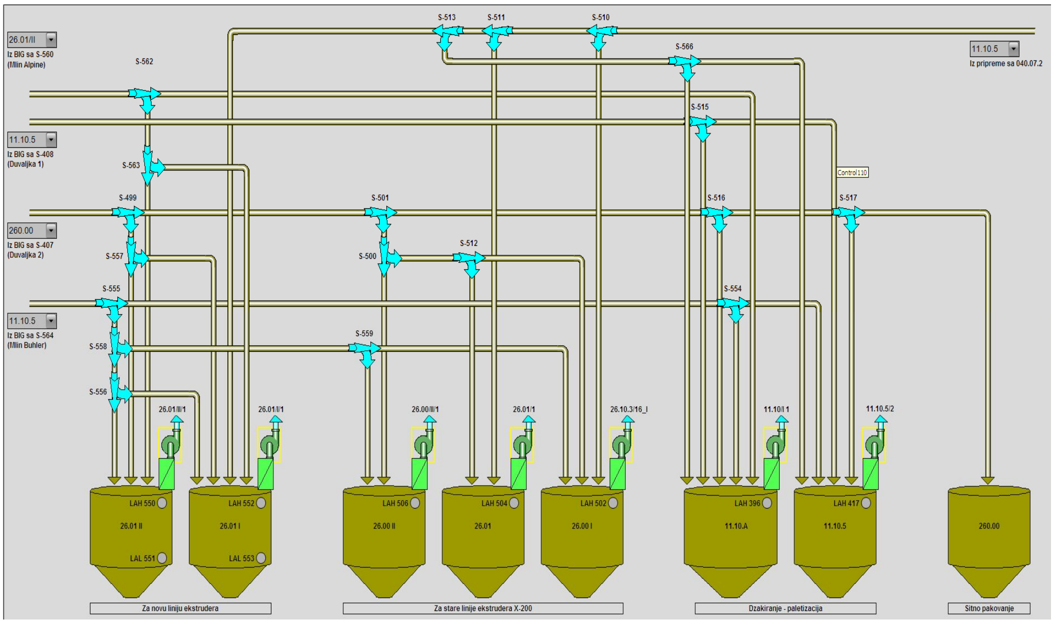

Fig. 2. SCADA graphical representation of the system

control system sets all the elements of the transport system to meets the requirements of the route.

The presented solution gives the freedom to select transport paths in different ways with respect to system checking conditions for a selected transport path. The graphic representation of the system uses clearly defined system elements, the dialogue for element control and the display of the selected and actual paths for transport. This gives a clear overview of the entire system and allows easy everyday usage in the production process (*Selakov at al., 2008*). The control system presented in this paper can be easily expanded with other function requests in any other production process and can be implemented in any other transport system. The created control system for transport is a solution based on the previous experience of creating and analysing similar systems.

CONCLUSION

A supervisory control system should meet the requirements of modern production. A practically realized system of pneumatic transport represents one of such applications. The system should provide full functionality in the user-friendly everyday use. This system is designed and practically implemented to meet this requirement, which is only possible by means of a modern supervisory control system. In order to implement the system, a set of experiences was gathered from end users with the application of the designed solution and the improvement of the practical usability. The system may provide a foundation to complex transportation systems in processing industry.

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