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A MODERN SCADA SYSTEM FOR THE HEXANE SOLVENT EXTRACTION DESOLVENTIZER-TOASTER IN SOYBEAN FLAKES PRODUCTION

MODERNO REŠENJE NADZORNO UPRAVLJAČKOG SISTEMA POGONA TOSTERA HEKSANSKE EKSTRAKCIJE U PROIZVODNJI SOJINIH FLEKICA

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ABSTRACT

This paper presents a modern SCADA system suitable for the production of soybean flakes, particularly the desolventizing-toasting process as a part of hexane solvent extraction. The system was tested and commissioned at the factory for soybean processing Sojaprotein a.d., Bečej in Bečej, Serbia. The observed production process consisted of two plants, one previously existing and the other newly assembled, running in parallel. The present system facilitated the increased productivity, efficient material and energy use, and easy control from a central control room. By means of this system, the operators were able to respond timely to unforeseen situations, which ultimately reduced the total production costs.

***Key words**: SCADA, process industries, soy processing.*

REZIME

Brz razvoj oblasti nadzorno upravljačkih sistema i njihova stalna unapređenja proizvode širok spektar novih rešenja u oblasti primene u procesnoj industriji. Unapređenja su većinom orijentisana ka omogućavanju efikasnijeg upravljanja proizvodnim pogonom ostvarujući bolju produktivnost, kvalitet proizvoda i smanjenje utroška sirovina i energije. U ovom radu je prikazano jedno moderno rešenje sistema za nadzor i upravljanje pogonom tostera u okviru heksanske ekstrakcije u procesu proizvodnje sojinih flekica. Sistem je testiran i pušten u rad u fabrici za preradu soje „Sojaprotein a.d., Bečej“ u Bečeju. Posmatrani proizvodni proces se sastoji do dva pogona koji rade u paraleli na identičan način, s tim što je jedan pogon opremljen kompletno novim uređajima dok je identičan paralelni pogon opremljen već postojećim uređajima koji su u potrebnoj meri prilagođeni da bi mogli da se koriste u sprezi sa nadzorno upravljačkim sistemom. Ovakav način realizacije omogućava opservaciju dva funkcionalno identična sistema sa različitim merenjima i izvršnim organima i njihovo poređenje sa stanovišta mogućnosti nadzora i jednostavnosti upravljanja. Primenjena iskustva iz analize dva funkcionalno identična procesa sa različitim mogućnostima upravljanja omogućuju sticanje novih znanja iz ove oblasti i kasniju implementaciju sličnih sistema u drugim pogonima procesne industrije. Realizovani nadzorno upravljački sistem obezbeđuje povećanu produktivnost, ekonomičnije korišćenje sirovina i energije i lakšu upravljivost sa centralnog mesta u komandnoj sobi. Osim toga, uz pomoć ovog sistema operateri imaju mogućnost pravovremene reakcije na nepredviđene situacije što u krajnosti smanjuje ukupne troškove proizvodnog procesa. Podaci prikupljeni tokom eksploatacije ovog sistema mogu biti iskorišćeni u svrhu poboljšanja produktivnosti i unapređenja kritičnih tačaka procesa.

***Ključne reči:** SCADA, procesna industrija, prerada soje.*

INTRODUCTION

The rapid development of information technologies over past decades has potentiated the need for modern supervisory and control systems in industrial plants. Such systems, providing software and hardware platforms for data acquisition and control at all levels, are called human-machine interfaces or (more specifically in industrial processes) supervisory control and data acquisition (SCADA) systems (*Bailey and Wright, 2003; Stuart, 2004*). Modern SCADA systems are subjected to increasing demands on their reliability, safety, promptness, robustness, and above all cost-effectiveness. Moreover, SCADA systems have to be user-friendly and they are expected to store all the requested information in one place (by means of a computer server in the control room). All information must be accessible to operators on demand, adjusted and presented in desirable formats. Some more important data have to be stored in databases for subsequent analyses.

The basic advantage of having a modern SCADA system in a processing plant is the centralized data acquisition and presentation of collected data on modern computers and smart devices (*Bugarski et al., 2011*). The most important task of a SCADA system is to process alarm events. Unwanted states and failure events must be immediately recognized and signaled to operators with alarm messages and, if necessary, with a sound signaling device (horn). Alarm messages are usually stored in the database for further assessments (*Bugarski et al., 2015*).

SCADA systems are positioned at the top of the control hierarchy (*Stuart, 2004*). At lower levels, the data are collected through sensors, transmitters, acquisition cards, measurement devices and other field machinery. Usually, a SCADA system communicates with Programmable Logic Controllers (PLCs) and other smart devices via the established industrial protocols. A PLC is a control unit, featuring a direct control program, which independently controls individual facilities. A SCADA system may indirectly assign the control tasks to PLCs. PLCs collect the data through the input acquisition cards (digital and analogue) and via communication networks. A PLC is positioned between a SCADA system (which is above the PLC) and sensors and actuators (which are below the PLC). The communication is bidirectional. The operator, through the SCADA system, gives control actions to the PLC, and the PLC provides the SCADA software with collected data.

This paper analyses the implementation of a modern SCADA system in two similar facilities, one equipped with old and the other with newly-designed machinery.

MATERIAL

Both toaster plants operate on the same principle and the production technology is the same as well. They can operate separately or in parallel. The material (soybean flakes) is transported from the extractor to the toaster with conveyors. In the extractor, oil is extracted from soybean flakes by a low boiler solvent treatment. The extraction process consists of treating the raw material with hexane and recovering the oil by distilling the resulting oil solution (miscella) in hexane. The evaporation and condensation from the distillation of miscella recovers the hexane absorbed in the material. The hexane thus recovered is reused for extraction. After the extractor, the treated material is transported to the toaster for drying, toasting, and cooling. The soybean toasting is very important because some of the components found in raw soybeans can cause short-term digestive problems, as well as possible long-term health issues.

Both toaster plants are controlled by a *Siemens S7-400* PLC with a central processing unit *CPU 414-3 PN/DP*. The PLC communicates via the PROFIBUS network with five distributed peripherals equipped with digital and analogue input and output modules and 18 frequency controllers running asynchronous machines. A part of the PLC hardware configuration is illustrated in Fig. 1. The figure shows the PROFIBUS connections between CPU, 5 distributed peripherals, 4 *Sentron PAC3200* power monitoring devices, and 10/18 *Danfoss FC300* frequency controllers. The PROFIBUS network is desirable when connecting a large number of industrial devices with various cable lengths (*Clarke and Reynders, 2004*). A detailed survey of connections in process industries with cost analysis is argued in *Nikolić et al., 2009; Nikolić et al., 2010a; Nikolić et al., 2010b*.

The SCADA system is designed with the *Siemens WinCC* environment. The software is running in parallel on two PC computers with the *Windows* operating system in the control room. This parallelism is done for the sake of redundancy. Both computers are equipped with two Full HD resolution monitors. The number of PCs and their structural organization (server-client) is very important in SCADA systems, especially when considering the prices of software licenses and robustness of the whole system. A detailed robustness and cost analysis with advantages and disadvantages is published in *Bugarski et al., 2014*. The computers are connected to the PLC through the same *Ethernet* network by the *TCP/IP* communication protocol. Operators can choose to monitor five different overview screens on each monitor. Two of them present all the necessary information from the each toaster plant (the old and the new), whereas the other three screens present the collected data from the database in the form of trends. Practical solutions of various SCADA systems in process industries can be found in *Bugarski et al., 2007; Bugarski et al., 2008; Bugarski et al., 2009; Bugarski et al., 2010, Nikolić et al., 2014*.

DISCUSSION

The SCADA system presented in this paper is implemented and maintained in Sojaprotein a.d., Bečej, located in Bečej (Serbia), which is one of the leading soybean processing factories in Europe. Two PCs in the control room are running the same software and operators can choose to monitor the desired screens on four monitors. There are two main screens for overall monitoring of the production process. They cover all the important information from the old and the new toaster, and they are presented in Figures 2 and 3, respectively.

All the data collected by the sensors are presented on these screens. The analogue measured values are presented in output fields, and the information from digital signals are presented with different colors of the machinery. There are three more screens presenting the historical data in the form of trends, and one screen for displaying the alarm and warning messages.

Two similar toaster plants are automated with the same PLC and the same SCADA system. Their operability is the same, but the first one is older and equipped with old machinery while the second one is newly-built. The implementation of monitoring and control systems was compared in these plants. The numerical results of the comparison are presented in Table 1. The results show that both plants have a similar number of drives, but in the new one, there are more control valves and more control loops showing that more process variables are automatically regulated. The older plant has a greater number of digital signals, whereas the new plant has a greater number of analogue signals. A greater number of frequency converters are especially noticed in the level regulation of the new toaster plant.

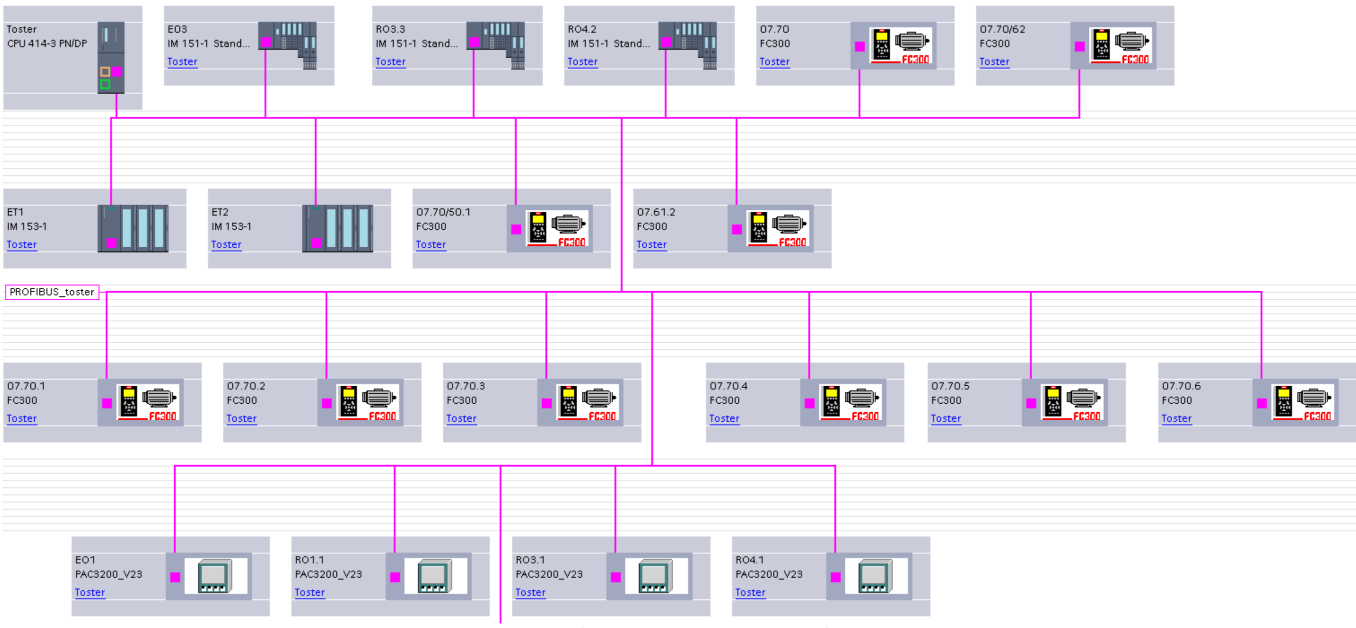

Fig. 1. Part of the PLC hardware configuration

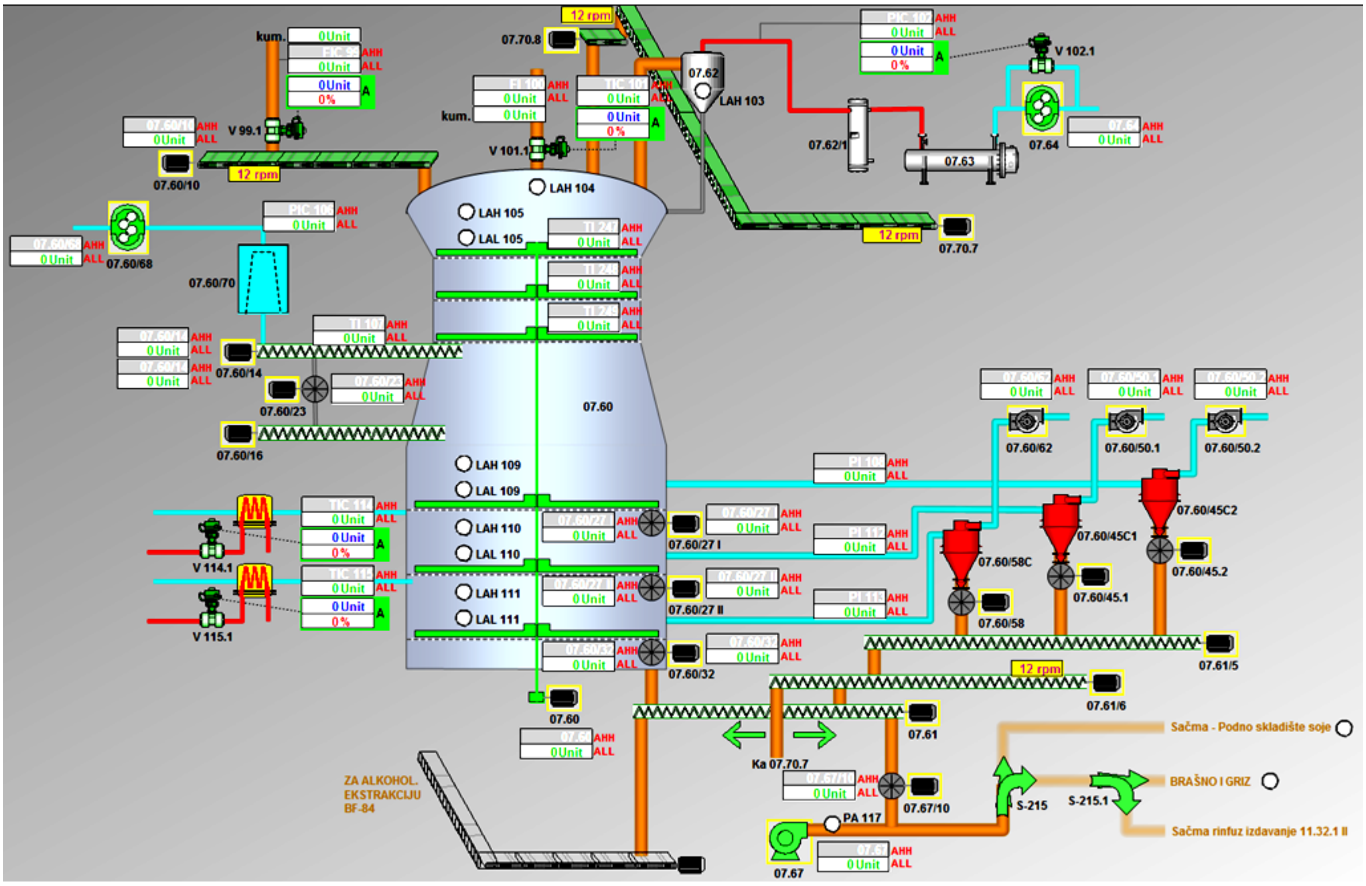

Fig. 2. Old toaster SCADA screen

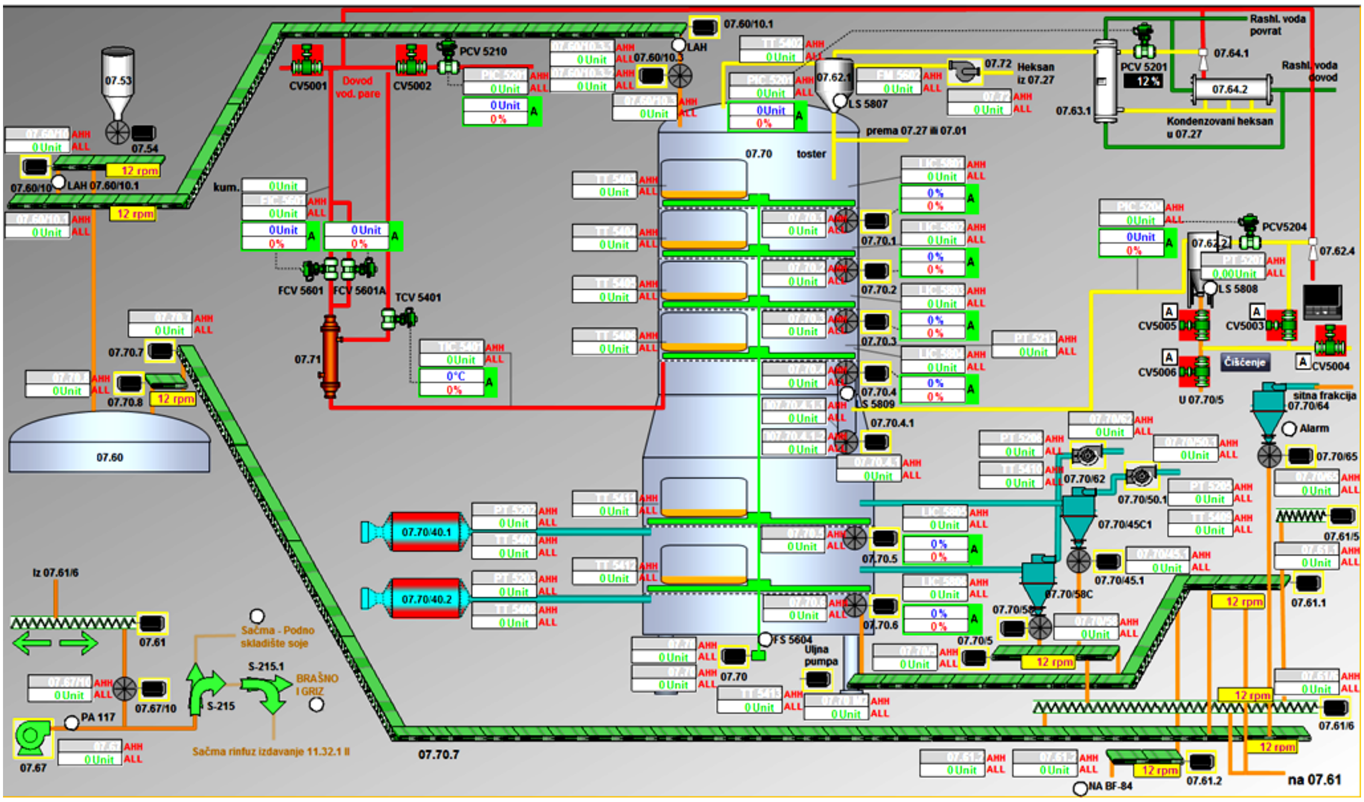

Fig. 3. New toaster SCADA screen

Table 1. Comparison of the two toaster plants monitoring and control systems

Comparison criteria	Old toaster plant	New toaster plant
Number of motor drives	30	29
Number of control valves	9	15
Number of feedback control loops	5	12
Number of digital inputs	108	71
Number of digital outputs	55	37
Number of analogue inputs	45	62
Number of analogue outputs	5	6
Number of frequency controllers	8	10
Number of external SCADA tags	2,905	3,429
Number of alarm messages	203	239

CONCLUSION

This paper presents a modern SCADA system designed for the hexane solvent extraction desolventizer-toaster in soybean flakes production. The SCADA system was implemented in two toaster plants, which were commissioned and tested at Sojaprotein a.d., Bečej. The comparison between the plants was made according to the number of drives, valves, signals, tags, etc. The results show that, in the case of the old toaster plant, the majority of signals are connected to digital signals, while in the case of the new toaster plant, a greater number of signals are analogue and a large number of them are transmitted via the PROFIBUS communication.

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