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Software Application for the Automation and Operation of a Natural Gas Compression Station

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Abstract

In the last years, in the context of introducing modern technologies to more and more industrial domains, there has also arisen the need to realise automation equipment and the corresponding software components for the domain of natural gas compression.The current paper presents a software for the monitoring, automation and data acquisition, implemented on a modern automation system for a natural gas compression station equipped with type C360 electrocompressors, as well as the results obtained following the testing of this software. The software allows the functioning of the equipment without local human supervision and in complete safety and also offers the possibility to send the equipment's functioning parameters at a distance in order to provide a SCADA-type control of the compression station. The main novelty element brought by this software for the monitoring of the compression process is that the operating graphic interface is realised in 3D, the operator having a realistic image of the automation system.

Key words: *software, compression station, monitoring, operating;*

Introduction

The most efficient method for the long-distance transportation of natural gases are the main gas pipelines. This is an usual method also for transmitting natural gas between producer and customers. One of the key objectives in the transportation of gas by this method is the ensurance of the customers' satisfaction through maintaning the gas pressure inside the pipeline [2]. This is done by means of a natural gas compression station.

The compression of natural gases represents one of the most important sectors of the gas producing industry in Romania. The compression stations can be equipped with compression equipment such as electrocompressors, turbocompressors and motocompressors, provided with electrical or pneumatic automation systems. However, generally, the original automation elements existing on compression systems currently in use in Romania present a very high degree of physical and moral wear and, moreover, they lack the possibility of transmitting the data related to compression stations at a distance and to process the data numerically. [1, 4]

Starting from these premises, there has been realised a software for the monitoring and operation of a gas compression station equipped with C360 type electrocompressors, with two compression stages, actuated by asynchronous motors with a power at the shaft of 900 kW and fed at a voltage of 6 KV, in pressurised construction.

The realised software leads to the possibility to reduce the exploitation personnel, to reduce the consumption of spare parts by increasing the reliability of the equipment and implicitly to reduce the compression costs.

The current paper presents the main characteristics of the developed monitoring and operating software, as well as the results obtained following the usage of this software.

The Architecture of the Automation System

An automation system facilitates the measuring of certain parameters, the analysis of the operational situations, the identification and adressing of abnormal situations, the studying of more profitable opportunities, the calculation and implementation of control measures, the information of the personnel, the optimal exploitation of their knowledge and abilities and not least the integration of all processes [3].

The realising of such a system implies the modernisation of the automation equipment for the compressors and the setting up of a room for the centralised command and control of the station, complemented with a general automation panel that allows the tracking and control of the functioning of both the compression equipment and of the compression station as a whole. By means of a process computer, it is possible to provide, using the general station keyboard, the remote control, the automated functioning of the machines, as well as the monitoring of the technological parameters, the position control and the remote control of the valves.

In this particular case, inside the control room there has been installed a general control panel for the compression station, executed in normal construction based on a PLC (Programmable Logic Controller) equipped with modules for inputs, outputs and communication selected adequatedly, called PLC-GCP (Programmable Logic Controller - General Control Panel). This equipment was designed to acquire both the general parameters of the compression station (pressures, temperatures, flows, valve positions, status of the centrals for fire and gases, oil heating installation, power distribution unit) and those of each compressor in part, also providing the centralised command of the functioning of the compressors, with possibilitieeesss to start them, stop them, putting them under load or disconnecting them. For this purpose, the PLC-GCP was equipped with a touchscreen on which there is implemented a graphical interface composed of several displays that can be accessed by means of virtual buttons created on the touchscreen.

The process computer is connected to the PLC-GCP and gets all information acquired by it, in order to display them, to archive them, to provide the possibilities for analysing their variation over time, but also to remotely transmit, via an intranet network, all information related to the functioning and evolution of the compression station's technological parameters. Through the proces computer, the operator has access to all controls needed for a safe and efficient functioning of the compression station.

Figure 1 presents the tree-shape architecture of the automation system for the targeted compression station.

For the control of the compressors' functioning parameters, the automation system uses local automation panners tablouri locale de automatizare bazate pe controllere programabile PLC-LC based on programmable controllers PLC-LCP to which there are connected both parameter transducers and the machines's execution elements. Each PLC-LCP is connected to an operating console consisting of a touchscreen by means of which the operator can visualise locally the machine's functioning parameters and the statuses of the execution elements, but can also intervene in the machine's functioning by means of manual commands entered by operating virtual buttons created on the touchscreen.

The operating console has three important functions within the general control panel:

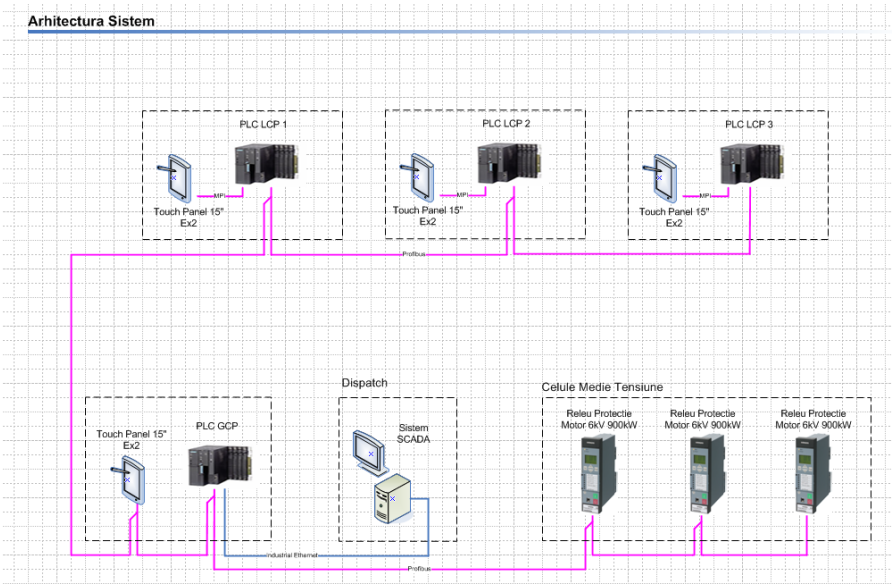

Fig. 1. The architecture of the automation system

- the acquisition of process data by communicating in real time with the local panels and the submission of the main technological parameters and of the aggregates' statuses to the dispatching point of the compression station, as well as the acquisition, by means of the own PLC-GCP programmable controller, of the compression station's general parameters and their presentation by means of an easily accesible graphical interface;
- the storage of all acquired data, for certain periods of time;
- the communication with the central dispatching point of the gas processing control unit in order to transmit the parameters or to receive from it commands for the coordination of the natural gas network.

Description of the Implemented Software System

Taking into account the need to optimise the functioning of the compression station, there has been conceived a software system with two components: the software for monitoring and operating the compression units and the software for the compression station as a whole. The software system was developed in the programming environment Labview, on the same structure as the automation system itself (fig. 1).

The software for monitoring and operating the individual compression units

The software is installed on the touchscreens corresponding to each local panel. It contains a graphical interface presented as a synoptic three-dimensional scheme of the compression unit displayed on the touchscreen, which presents, in real time, information on the status of the machine, its technological and functional parameters, also allowing the operator to control the predefined sequences for preparing the startup, stopping and operating the unit and to stop them whenever this becomes necessary.

The graphical interface comprises as main elements the main menu, the visualisation window and a set of static elements.

The software's main menu comprises a series of buttons that allow the opening of separate pages for groups of monitored parameters. As can be seen in Figure 2, it is possible to display in real

time several parameters on a single page, which allows the operator to see in a short time span any functioning problems of the machine. The displayed values can also be visualised as graphs in real time.

For example, an important page within the software displays, using LEDs the functioning stage of the oil pumps, the position of the manual actuation lever and the status of the oil heater for the engine's oscillating bearing.

The software also offers the possibility to visualise the variation of parameters by means of virtual analogical indicators, either directly on the 3D image of the compression station (fig. 3), or in separate windows.

Because there are informations that need to be displayed independently from the opened page, the on the touchscreen there are static areas with command elements and indicators that do not disappear when navigating through the pages of the graphical interface. (fig. 2) These static elements include:

- the header, with the authentification field and page navigation controls; the header also contains a display area which provides information on the current status of the machine;
- the signals bar (alarms, warnings, communication status, status of the warning lamps);
- settings buttons and access to the service page;
- a controls assembly for start/stop commands.

Other useful information provided the software are the status of the compressor's lubrication circuit, the list of alarms, the events history, the list of real-time graphs etc.

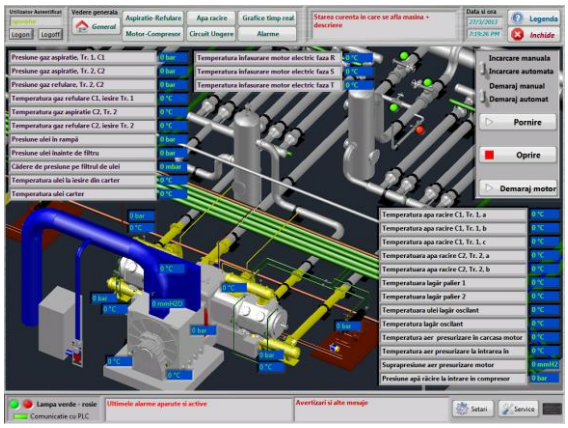

Fig. 2. Overview of the graphical interface for monitoring and control, with lists of technological parameters

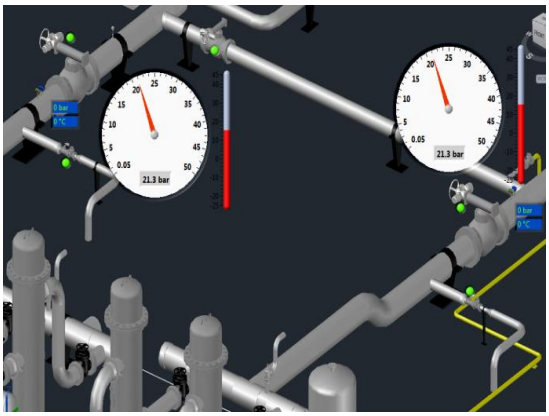

Fig. 3. Display of the values of technological parameters on virtual indicators in analogous format

The software for monitoring and operating the compression station as a whole

The software for monitoring and operating the compression station as a whole contains a graphical interface with a three-dimensional synoptic scheme similar to that from the software for the individual compression units. It should be mentioned that this software also realises the centralisation of data coming from the individual compression units and from all components of the station.

All functioning parameters of the individual units and of the station as a whole are fed into the system and are available at the process computer, where they are stored in a database, so that the operator can analyse both the variation of parameters over time and a series of personalised reports whose structure can be defined according to the user's demands.

Results and Discussion

In order to evaluate the accuracy of the developed software for monitoring and operating the compression station, this software was implemented on the automation system of a compression station equipped with C360 electrocompressors and was tested in prototype phase, tracking its functioning both during a stop/restart phase and during the normal functioning regime. The obtained results also allowed to assess the electrocompressor's efficiency and its wear status.

Figure 4 presents the variation diagram of the aspiration temperature (Tasp) and of the discharge temperature for the compression cylinder of an electrocompressor (Tref), for an hour of functioning, during which there the system was stopped and then restarted. Since the nominal temperature of the discharge gases, recommended by the producer for this type of electrocompressor is of maximal 120°C, the graph from Figure 4 indicates an adequate functioning of the system and an acceptable degree of wear.

From Figure 4, it can be noticed that, at minute 7, the machine was taken off charge, which led to a slow decrease of the discharge temperature, at minute 13 the machine was stopped, which meant that the gases in the discharge pipe start cooling at a higher rate so that at minute 18 they reach a temperature that is approximately equal to the aspiration gases. At minute 33 the machine is restarted in idle mode, the gases being recirculated through the bypass valve, at minute 40 the machine is being brought to normal functioning mode and at minute 46 the compressor finally returns to a stable functioning regime under nominal charge.

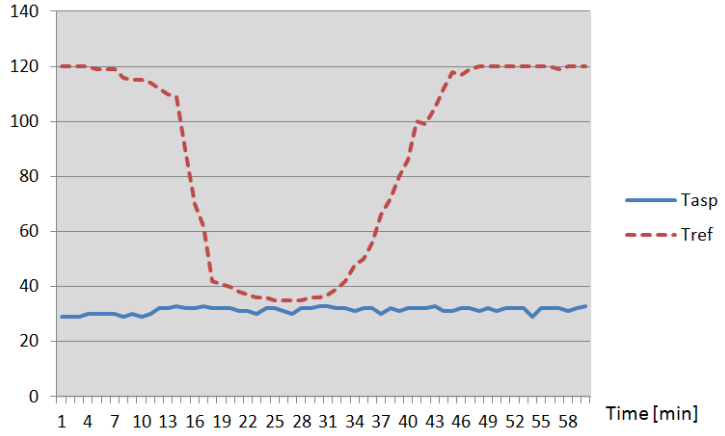

Fig. 4. Variation diagram for the aspiration and discharge temperature for the compressor cylinder of an electrocompressor, as generated by the developed monitoring and operating software

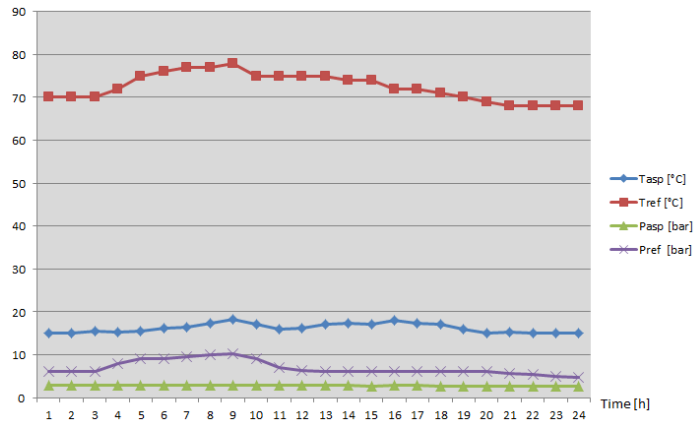

Fig. 5. Variation diagram of the main functioning parameters of the electrocompressor, generated with the help of the developed monitoring and operating software.

Figure 5 presents the variation of the main parameters of an electrocompressor: the aspiration temperature (Tasp), the discharge temperature (Tref), the aspiration pressure (Pasp) and the discharge pressure (Pref) over 24 hours, in normal functioning regime. It can be noticed that during this time frame, the machine did not function at nominal capacity, so the temperature of discharged gases does not reach the maximal value recommended by the producer (120°C). Also, it can be noticed that the temperature of the discharged gases increases with the increase of the discharge pressure, under the conditions of an approximately constant aspiration temperature and of a constant aspiration pressure. This is due to the increase of the compression rate, itself due to the variation of the gas consumption in the transportation network. Such a variation of the machine's parameters indicates a normal functioning of the compressor cylinders.

Conclusions

This paper presented the main characteristics of a monitoring and operating system developed for a natural gas compressiom station equipped with C360 type electrocompressors.

The implemented software allows the acquisition of data in a process computer and the visualisation on different time intervals, but also provides the possibility to compare the parameters of the different compression units within the compression station.

The testing of the software in prototype phase, both in a stop-restart regime and in long-time functioning regime, have revealed its capability to assess and display the compression station's status adequately. Further improvements of the software will increase the communications capabilities and the accuracy of the displayed data.

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Aplicație software de automatizare și operare a unei stații de comprimare a gazelor naturale

Rezumat

În ultimii ani, în contextul introducerii tehnologiilor moderne în tot mai multe domenii industriale, a apărut și necesitatea realizării unor echipamente de automatizare și a programelor corespunzătoare în domeniul comprimării gazelor naturale. Lucrarea de față prezintă un program de monitorizare, automatizare şi achiziţie de date, implementat pe un sistem de automatizare modern, aferent unei stații de comprimare gaze naturale echipată cu electrocompresoare C360, precum și rezultatele obținute în urma testării programului. Programul vizat permite funcţionarea agregatelor fără supraveghere umană locală şi în deplină siguranţă, precum şi posibilitatea transmiterii la distanţă a parametrilor de funcţionare a acestora în vederea asigurării unui control de tip SCADA a stației de comprimare. Elementele de noutate pe care le aduce acest program de monitorizare a procesului de comprimare este faptul că interfața grafică de operare este executată 3D, operatorul având o imagine realistică a instalației de automatizare.