Considerations on the optimization of natural gas deliveries by using automated control systems

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Abstract. The current paper aims at optimizing the natural gas deliveries from an underground storage by implementing automated control systems and fiscal measurement systems according to the harmonized European legislation in the area of metrology. In the first part, the authors have carried out an analysis regarding the state of the art at international level with regard to technical solutions for optimizing the deliveries of natural gas by means of a constriction element of a measurement panel. In the following, a software application was created for monitoring the parameters taken from the process gas chromatograph and transferring them to the flow computer by implementing software filters. The novelty element here is that it allows the trading of the nominated natural gas amount in a set period of time.

1 Introduction

Even if in the last few years renewable energies seem to be dominating the discussion on energy sources and many researches focus on finding new types of fuels [1-2], natural gas still remains one of the most important energy sources, both for companies with industrial activities and for residential users. However, given the strict legislation in this domain [3-5], all equipment related to the transportation and delivery of gas has to be built while keeping in mind several rules and standards.

The demand for the supply with natural gas can have important variations, determined especially by differences in the amount required for the heating of residential, administrative or commercial buildings from summer to winter, from normal winter days to winter days with very low temperatures, from peak hours to hours with minimal consumption etc. [6-8]. These variations can be shown by plotting the so-called “load curves”, that allow the identification of seasonal, daily or hourly consumption peaks, differing in aspect from consumer to consumer, from one economic sector to the other, from one locality to the other, or even from one hour to the next for the same consumer or group of consumers [6 - 7].

The constant balancing of the natural gas demand with the available sources has to be viewed also from the perspective of changes in these sources. The changes can be caused by

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decreases in the level of local or national production or in the level of imports, determined in turn by a wide range of reasons: technical, financial, political etc. [6, 9].

Natural gas storage facilities can mitigate the impact of changes in consumption and the effects of a temporary reduction in supply either from the internal production or from imports as well as the consequences of uncertainties in predicting the consumption [9].

Given the high value of the natural gas, it is very important to be able to ensure an accurate measurement and adjustment of the natural gas amounts that needs to be delivered to consumers and to make sure that the equipment employed for this purpose is up-to-date.

One of the most important features of modern systems is automation, and especially the possibility to automate the control of technological systems, so as to minimize the need for human operators to interact with those systems and to make sure the values of tracked parameters remain within designated limits [10 - 11].

In the current paper, the authors present a solution for the provision of an automated adjustment of the flow of natural gas by introducing an electrically actuated control valve and by replacing the existing membrane-based measurement panel with a new fiscal measurement system, with approval of metrological model and a new automation panel that allows the implementation of an adjustment function for the corrected gas flow, in volume units or in energy units.

2 The currently used system

The measurement system that had been selected for replacement was realized with a diaphragm fastened to flanges and uses a ROFAR 03 Ex flow meter (Figure 1 [12]).

ROFAR 03ex can measure and register the volume and higher calorific value of natural gases on 1-4 measurement systems. The gases’ compressibility is measured according to ISO 12213-2 and ISO 12213-3, while the higher calorific value is determined according to SR ISO 6976. The gas flow is calculated according to ISO 5167-1/2003. Each measurement system consists of a measurement segment, diaphragm, pressure transducer, differential transducer and temperature transducer. The users can configure the number of active lines, the function carried out by each line and the corresponding parameters, the physical parameters valid for all lines, as well as the composition of the gas.

Fig. 1. ROFAR 03Ex flow meter [12]

However, currently there are no possibilities to ensure an automated functioning of the gas measurement and delivery panel, because the only implemented automation function is the fiscal measurement of the delivered amounts of natural gas and in the technological installation there are neither execution elements nor equipments for the automated control, adjustment or protection that could allow a functioning without the intervention of a human operator.
All actions for modifying the gas flow have to be executed manually by the operator, who intervenes directly on the mechanically-actuated valves within the technological installation in accordance with the decisions made based on the gas amount that needs to be delivered and on the instantaneous flow values read from the flow computer.

3 The implementation of a new automated gas flow adjustment system

Due to the fact that the existing technological installation does not allow the automated adjustment of the gas flow, the authors designed and implemented an automation solution consisting in the installation of an automated control system comprising a pressure balanced plug valve.

This valve is a SERCK AUDCO SUPER-H 20 pressure balanced plug valve (Figure 2 [13]), class 150 – API 6D, model HVN 233, equipped with a mechanical demultiplier and an electrical actuator BIFFI WGRM 320 + ICON 030R/360-20.

![Fig. 2. SERCK AUDCO SUPER-H 20 pressure balanced plug valve [13]](image)

In order to allow the possibility of an automated control of the gas flow, the new implemented fiscal measurement system is configured to provide a flow signal of 4-20 mA to the control system, proportional to the instantaneous value of the flow expressed either in volume units or in energy units.

Thus, the new natural gas measurement system consists of following elements:

- CDM-GN multistream gas flow computer produced by FEPA S.A. Bârlad.
- Port-diaphragm equipped with fast disk extraction system, with upstream/downstream segments type DST version E2+T, according to S.G. DST609T, producer FEPA S.A. Bârlad, system containing also a reserve disk and a sealing kit.
- Multivariable transducer (SP, DP, RTD) TCM, according to SG 779M rev. 5, type TCM B.02.05.A.64, produced by FEPA S.A. Bârlad.

Figure 3 shows a screen capture with the technological parameters of the new measurement system, the measurement ranges of the pressure and temperature transducers and the values recorded with these transducers.
The instantaneous natural gas flow is determined by the flow computer based on the parameters received from the corresponding transducers, installed in the measurement points (ΔP, P, T). Initially, the flow computer will be brought to the standard state by realizing pressure and temperature corrections, after which, based on the composition of the gas mixture, taken from the process gas chromatograph YAMATAKE HGC303, there can be calculated the amount of energy transiting through the pipeline in a time unit.

The communication with the gas chromatograph occurs via a serial communication bus RS 485 using the protocol Modbus RTU. The flow computer also calculates the amounts of gas and of energy transiting through the pipeline every hour, day, month or at time intervals set by the beneficiary, the real time clock being synchronized with the one on the TRANSGAZ SCADA system, with which it communicates in order to transmit data on a RS 232 bus using the communication protocol Modbus RTU.

All these data are received both by the TRANSGAZ SCADA system and by the automated control system, that can transmit them either to the dispatch or to a series of mobile devices connected to the internet, while providing the necessary security requirements - SIM card with static IP, with a password and user name chosen by the beneficiary. The access to data is secured and there are used passwords and user names corresponding to access levels determined in agreement with the beneficiary.

Beneath the function of receiving data and then transmitting them at a distance, the automated control system also carries out the automated control of the electrically actuated gas valve, in order to maintain a predetermined gas/energy flow or in order to allow the transiting of a certain amount of gas in a time interval set by the beneficiary, from the system operating console, situated in the local control room.

Figure 4 shows the main components of the installation and the manner in which these components are interconnected.

There can be identified two main parts, namely on the one hand the fiscal measurement system, consisting of the portdiaphragm and the calibrated measurement segments, the electric switchbox with the measurement transducers and the flow computer and on the other hand the electrically actuated taper plug valve. The two parts are connected to the automation panel, while the flow computer is connected also to the line gas chromatograph and to the TRANSGAZ SCADA system.

The transmission of data to a process computer at another location or to other mobile systems is done by means of the controller from the automation panel, equipped with a GPRS communication module.

The flow computer is powered at a voltage of 12 V CC by means of a solar panel equipped with batteries and with automated charging system, installed in the area without explosion risk. Also, by using an adequate power source and a voltage adder, there can be provided also a powering via the automation panel. The installed power in the whole automation system is of around 3 kW, of which approximately 2.5 kW are used by the electrically actuated control valve. This has a random intermittent functioning regime, depending on the control requirements in the process.

The measurement system is fiscal and has, in this regard, all required authorizations and permits from the competent authorities. It allows the measurement and displaying of energy readings (MWh) with a precision of 6 decimals.
Fig. 4. Schematics of the new automation system

Figure 5 presents a screen capture with the parameters displayed by the implemented system.

Fig. 5. Screenshot with the parameters displayed by the implemented system.

The system complies with the legal requirements regarding the explosive atmospheres/environments, both concerning the individual parts and concerning the assembly.

The system provides for the downloading of daily and monthly reports by connecting a laptop to a serial port of the flow computer or by transmitting the data off-site by means of GPRS.
The communication port for the automated control system will be used also as configuration port for the case in which it is necessary to configure the flow computer.

The flow computer communicates on the three available serial ports as follows:

- Port 1 is the port that will be used for the setup through a physical connection to a laptop running a dedicated software that is provided together with the equipment. When no setup is run, or no data are downloaded directly on the laptop, this port will be used for reading the data from the flow computer by the SRA.
- Port 2 is the port that will be connected to the process gas chromatograph and by means of which the flow computer will read data from the gas chromatograph.
- Port 3 is the port that will be connected to the SCADA system, by means of which the SCADA RTU will read data from the flow computer.

In order to provide the possibility of introducing filters for the concentrations of the processed gas, the gas chromatograph will be connected to the SRA system and the flow computer will read these data on another SRA port, so that it excludes the possibility of the flow computer using erroneous concentrations of the components should the gas chromatograph be defective.

4 Conclusions

The current paper has presented an optimization solution for natural gas deliveries using an automated control system that reduces the need for human intervention in the process. Further advantages of the new system are related to the reduction of measurement errors and to the increased precision in determining the delivered amounts of gas.

In future, the authors intend to continue their researches in order to optimize the described automation solution and to increase the accuracy of the data provided by the system.

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