Analysis of Dense Gas Distribution Networks by Means of Griding Technique

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Abstract

This paper is devoted to the analysis of work of medium and low-pressure gas network by means of conventional steady state simulators and griding contouring software. One of the objectives of analysis of network is searching possibility to extend of system in different pressure regimes, different gas demand of consumers because of developing of new infrastructures.

The coupled analysis of networks using classical steady state simulations and griding techniques allow finding the area, where critical velocity of gas has been reached. The main advantages of procedure is possibility to calculation of pressure gradient map, flow velocity map, pressure depression map, the Reynolds number map using simple mathematical grid transformation. The necessary condition to perform such analysis is full description of local coordinates (GIS) in the calculated network. The paper shows methodology for performing such analysis and examples of calculation of medium pressure dense networks.

Key words*: the analysis of work of medium, gradient map,*

Introduction

The purpose of this paper is to present techniques of using a numerical simulator, which would be efficient in terms of the complexity of an algorithm and a program analyzing variation of isobars by means of point kriging. Kriging is the estimation procedure used in geostatistics using known values and a semivariogram to determine unknown values. The procedures involved in kriging incorporate measures of error and uncertainty when determing estimations. Based on the semivariogram (eg. spherical, exponential) used, optimal weights are assigned to unknown values in order to calculate unknown ones. since the variogram changes with distance, the weights depend on the known sample distribution (Surfer, 2002). It is to specifying a numerical method range of influence of gas stationary states for high-customer density. During specifying range of station the boundary conditions in a supply point was appointed (constant: pressure). To conduct specification of contours numerically it is obligatory to determine gas flow in pipeline and distribution of pressure in net knots and create map of isobar and/or gradient maps for pressure as a function of x-y dimension. These problems are solved usually with a use of simulation software. The main purpose of applying the simulation software is investigation of behavior of gas net in specific conditions based on mathematical models. However, for instance, the method of inputting data or simplicity of interpretation of results on the computer screen is also very vital for the user of the program. It is requires a wide-range of features, which should be fulfilled by a good simulation software packet (Galbarczyk & Górecki, 1997):

- program should analyze every delivered gas net, no matter how many elements and knots belong to the net, except for extreme examples,
- it should be possible to determine variable sources of supply of the net with a constant pressure or various output pressure and with a constant rate of the source,
- it is advised to take into consideration other non-pipeline elements in the structure of the net (compressors, regulators, valves) and define specified conditions of working of this units,
- all types of gas net simulations ,i.e. low and medium pressure, is required,
- it is necessary to verify the flowing equation based on the network conditions, such as range of pressure, type and quality of pipes, regime of flow,
- it should be enabled the possibility of simulation of gas flow of various composition,
- various materials applied to construction of pipelines should be taken into consideration in the project.

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Fundamentals of simulation of gas distribution networks

In the conducted simulations of distribution, networks are usually used simulation packets type: GasSys, Stanet, SimNetSSV, Pipeline Studio, Gaz SC (Kordasz 1997, Stanet 1999, Osiadacz et al. 1999, Osiadacz 1996). The fundamentals of algorithms of the static simulation (simulations in the determined condition) in the application are the Kirchoff's equations and the flow equation. Pressures in knots and flows in branch have to fulfill the flow equation and together with customer demand, values have to fulfill the first and second Kirchoff's law. As a result, the Kirchoff's laws are fundamental to construct every single algorithms of static simulation (Nagy, Olajossy, Siemek 2004).

Description of analyzed distribution networks of medium pressure with two sources

The example of this analysis relates to the distribution network of medium pressure supplied from two opposite directions by 0,4 MPa pressure. The network is presented in the fig.1 (Olajossy et. al. 2004). For the network presented on the foregoing figure constructed in a PE technology the standard distribution of pressure based on given geometrical properties of the network and at constant pressure supplied in two basic stations at the level of 4.5 and 4.2 bars, calculations in a customer's point. By using the geodetic information, GIS (Geographical Information Systems), for every customer receive point it is possible to generate isolines of pressure in x-y coordinates presented on fig.2. The map of pressure gradient is displayed on fig. 3. It was constructed based on results of a static simulation at pressure in the supplying point of 4.5 bars in the R_a station and pressure of 4.0 bars in the R_b station. Concentration of lines and high values of gradients are presented in the middle part of fig. 3. The analysis of fig. 3 allows specifying assumed zones with turbulent flow and high hydraulic resistance resulting from improper design of network structure or change of load in the areas.

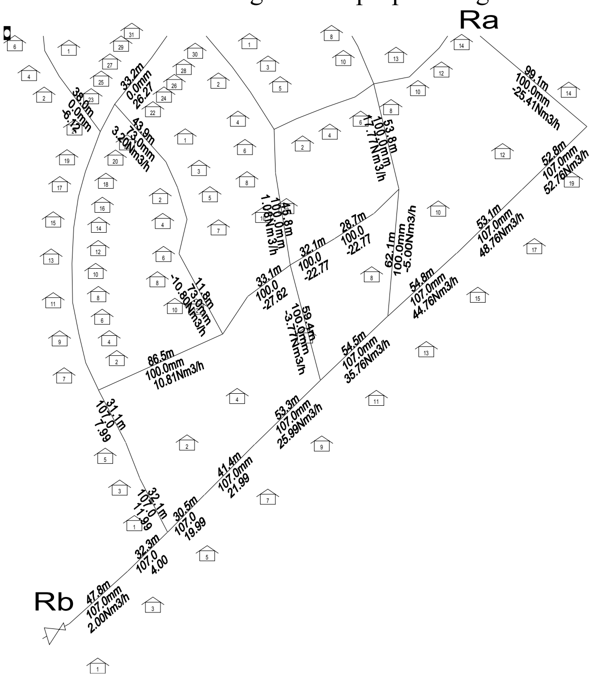

Fig. 1 Example of the distribution network of medium pressure with given pipeline lengths, diameters and gas flows

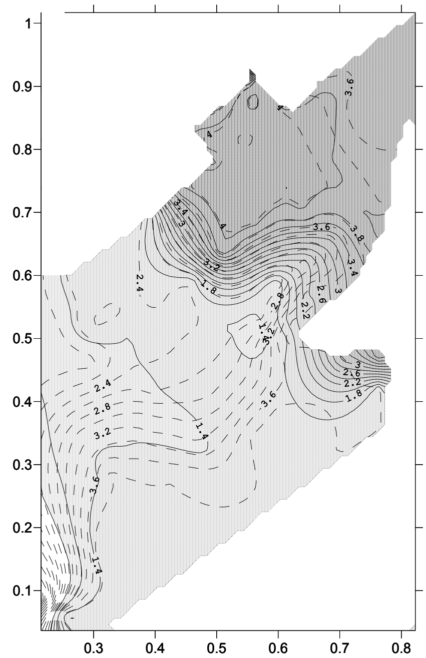

Fig. 2 Comparison of isobars for example of supplying from a single station of 4 bars pressure (solid line) and supplying by two stations (R_a and R_b) at constant pressure of supply of 4.0 bars (dotted line)

In fig. 4 the pressure contours for distribution net (two gas station R_a-R_b (supply pressure: R_a=4.5 bar & R_b=4.0 bar) – solid line; supply pressure: R_a=4.0 bar &R_b=4.5 bar) – dotted line) are presented. The moving of pressure contour is shown when change of pressure in the supply station is given.

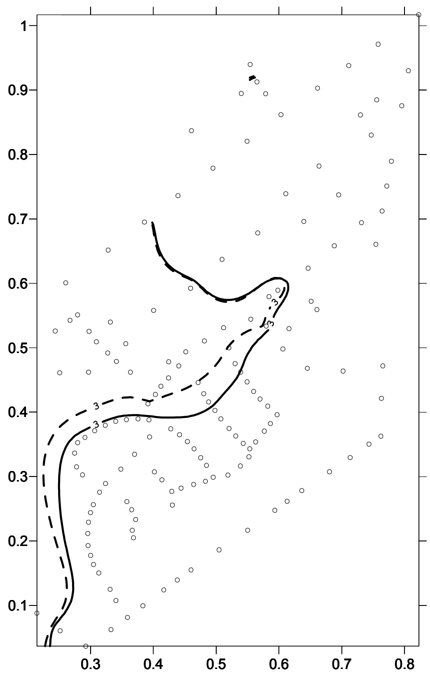

Fig. 3 Gradient pressure map (two gas station R_a-R_b (supply pressure: R_a=4.5 bar & R_b=4.0 bar)

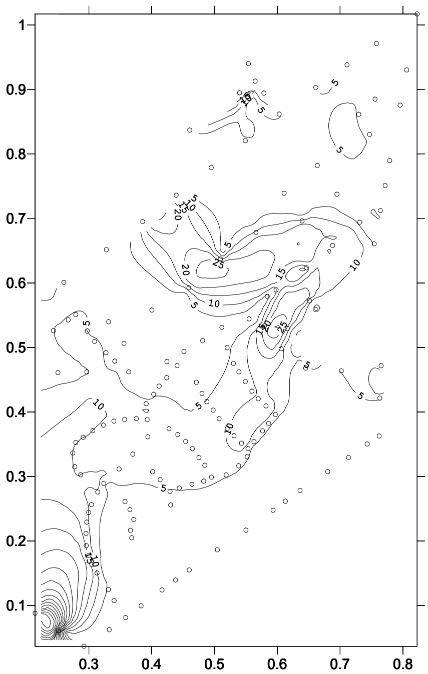

Fig. 4 Pressure contour for distribution net (two gas station R_a-R_b (supply pressure: R_a=4.5 bar & R_b=4.0 bar) – solid line and supply pressure: R_a=4.0 bar &R_b=4.5 bar) – dotted line)

Conclusions

1. Application of the point kriging method in specifying critical phenomenon in the distribution network of high density of customers allows determining the optimum place to install an additional supply or increasing the flow capacity of the network.
2. Presented on fig. 2 counters of isobars of the dense distribution network allows to observe phenomenon of moving supplying zones from the gas stations (R_a and R_b). If pressure is increased to 4.5 bars in the Rb station, it is noticed a decline of efficiency by 4.7% in the first station (R_a) and boost of efficiency by 23% in the second one (R_b). Consequently, variation of supply from four bars to 4.5 bars leads to increasing of supplying area as shown on fig.3 between 16 and 23% depending on direction of increased flow.
3. The analysis of pressure gradients in the network (fig. 3) allows specifying critical areas of the network, which are open to the highest velocities of flow caused by the highest declines of pressure in the southern and middle part of the network .

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