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THE TRANSFORMATION OF EXISTING NATURAL GAS NETWORKS OF REDUCED PRESSURE IN THE MEDIUM PRESSURE

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Abstract: *The work presents a technical-economic investigation which present solutions for natural gas network rehabilitation in order to find the optimal solutions. Six representative variants are proposed with branched or annular network systems, of medium or reduced pressure achieving real combinations having a complexity similar with the system of a medium city. It is demonstrated that by changing the actual reduced pressure branched network in annular network, the maximum flow capacity increases two times and more, setting the conclusion that by changing the low pressure network in medium pressure network is not necessary to re-size the duct in order to take over the new consumers due to the economical development of the region.*

Key words: *urban works, efficiency, performance.*

1. Introduction and Objectives

The exterior networks are a part of the natural gas distribution system, consisting of pipes, fixtures, fittings and accessories that take over the gas from station and transport it to valves of consumers connected to the low pressure or to the exit of the gas pressure regulating stations installed at ends of branching.

The exterior natural gas distribution networks can be ring branched geometric configuration, supplied from a single point (a single station adjustment-measurement – SAM) or more points.

In a more extensive study the authors have proposed to establish by calculating the optimum technical and economical constructive variant of a distribution system, analyzing the following conditions:

-the possibility of increasing the pressure in the distribution system by regulators from a reduced pressure to medium values of pressure;

- decommissioning sector adjustment stations (SAS);

-interconnecting medium pressure pipes with low pressure ones.

The necessary data for the calculation of a gas distribution network are:

- The scheme of the network;
- The length of sections [km];
- The effective distributed flow for each section Q_{SI} [m_s^3/h]; the calculation flow Q_{SI} (distributed + transport) results from the summing up;

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- Standardized diameters possible in that network, including the minimal admitted technical diameter $D_{min\ ad}$ [cm]; all diameters are considered as inner diameters of pipes;
- The maximal admissable pressure fall $\Delta Pmax = P_1 - P_2$, between the minimal pressure at the feeding point, P_1 [bara] and the necessary minimal pressure in order to assure the maximal level of pressure necessary to the fartherest end user from the feeding point or at the end of each final sector P_2 [bara].

The dimensioning calculation intends to identify the diameters of all sectors so that the total pression fall ΔP, on whatever sector, to be less or at most equal to ΔP_{max}, and the cost of the network to be minimal.

In the dimensioning calculation of the annular double or multiple supply networks we will keep in mind the different phenomena:

- The repartition of the total flow, both for the satisfaction of uniformely distributed consumptions in the system and for the assurance of concentrated consumption, the distribution of the flow being varied depending on the flowing direction and on the functioning state of the network;
- The supplying stations will be positioned in such a manner so that the gas surplus to be headed towards consumers;

This positioning of the supplying stations will determine gas flows along closed sectors, their sectors being able to assure the transportation of similar charges.

The situation is more frequent with annular networks of medium pressure where between the diameters of the successive sectors there should not be a difference bigger than a class (15÷20%).

The expenses will not be much more significant than 5÷10% as compared to the situation when from calculations would result greater differences between the diameters of the sections, from feeding to the end.

Another differentiation that one must take into consideration when dimensioning is the following.

- In the case of end branched out networks, unknown for each section are the diameters d_i of the sections and pressure fall ΔP_i, thus each sections creates two unknowm values;
- In the case of annular networks, due to the variation of gas distributed flux, each section creates three unknown values: d_i, ΔP_i and Q_i.

The great variety of situations which appear in practice has imposed the necessity of defining a' standard problem'. The standard problem for external natural gas distribution networks has been thus conceived that, on the one hand, to cover a field as large as possible of the cases which appear in practice, and –on the other hand – to allow the introduction of the data basis of the particular cases in the conditions of the standard problem.

2. Materials and Methods

A comparative study was performed on six variants of an investment project having as object the supply of gas to a locality.

The total flow of natural gas is 31083 Nm^3/h. It is anticipated that the total revenue of 607533 thousand RON will be obtained in a period of 50 years. The differences between these variants result in different values of investment (due to different results of networks dimensioning), execution time, technical, technological and constructive solutions. [1]

The comparative study to the six variants is presented in the next subsection.

2.1 Network types and models– systems optimization

Variant 1:

A first dimensioning was taken for the following structure of a distribution system, figure 1:

- supply of high-pressure transport network in transport networks in three points through three adjustment-measurement stations (SAM) which regulate the pressure of the high pressure at medium pressure;

- medium pressure distribution networks from the three SAMs to ten sector adjustment stations (SAS);

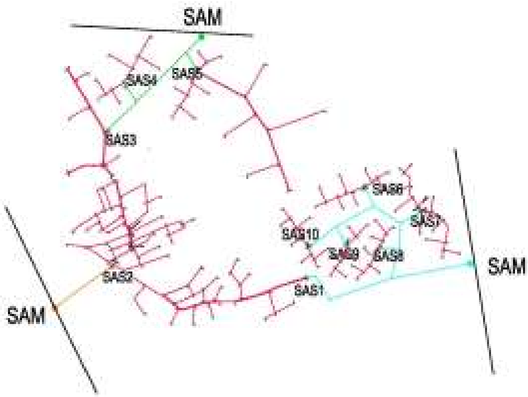

Fig. 1. *Constructive variant 1 of natural gas distribution network*

- ten sector adjustment stations (SAS) which reduce the pressure from medium pressure to reduced pressure, located in different parts of the system;

- distribution networks branched to reduced pressure, the pressure at the exit of SAM is 1.8 bar and the minimum pressure is 1.25 bar.

The total length of the distribution system is 54,005 km.

Variant 2:

In this variant of reduced pressure distribution, presented in figure 2, the network turned into the medium pressure distribution with the network being supplied from a single point, 10 SRS decommissioned and medium pressure pipelines interconnect with reduced pressure. Supply is assured from a single point and it will contain two SRM.

The SAM which will supply the whole network will be dimensioned for a 31083 Nm^3/hour flow.

The increased pressure in the distribution system has incresed from 1.8 bar to 3.0 bar, considering pressure loss for most disadvantaged branches of 0.8 bar and 2.2 bar minimum pressure.

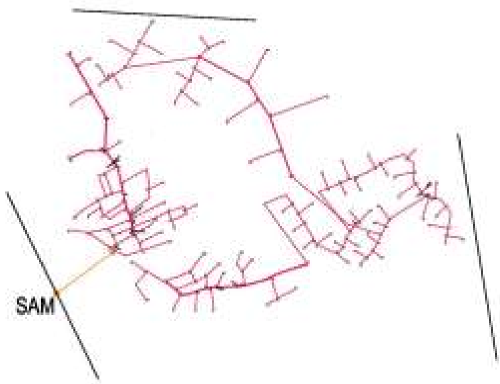

Fig. 2. *Constructive variant 2 of natural gas distribution network*

Variant 3:

In order to study the evolution of diameters depending on pressure, we will increase pressure in the network configuration of variant 1, which is supplied in three points.

The existing network was transformed from a reduced pressure network into a medium pressure network (3.0 bar inlet pressure, minimum pressure of 2.2 bar).

In this configuration 10 SAS are disposed of three SAM are maintained.

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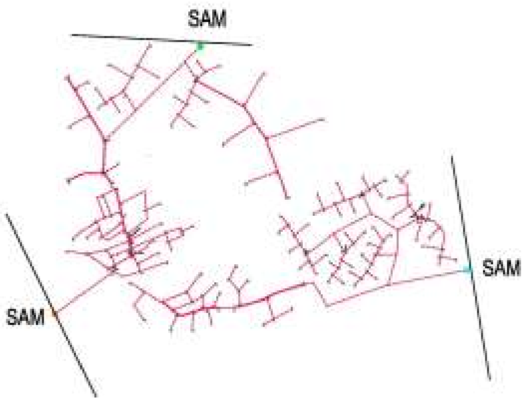


Fig. 3. *Constructive variant 3 of natural gas distribution network*

Variant 4:

The branched network transformed in ring medium pressure network. In this variant, figure 4, it was considered that the network will be supplied through three SAMs, which will adjust the output pressure to 5 bar.

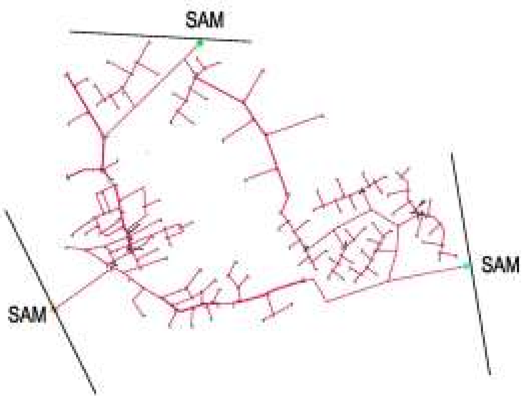


Fig. 4. *Constructive variant 4 of natural gas distribution network*

Variant 5:

In order to compare the technical and economic calculation between a branched network and a ring network, a branched distribution network with three supply points was simulated (similar to variant 3) presented in figure 5, a maximum pressure of 5.0 bar at the exit of SAM and minimum pressure of 4.2 bar.

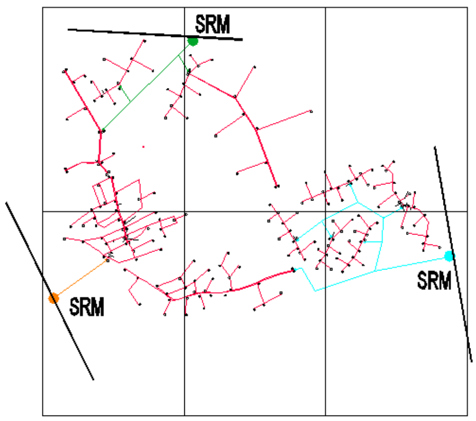


Fig. 5. *Constructive variant 5 of natural gas distribution network*

Variant 6:

In order to demonstrate the necessity of increasing output SAM pressure to 5.0 bar and the advantages of the ring network a branched network with a single supply point is dimensioned and presented in figure 6(similar to variant 2).

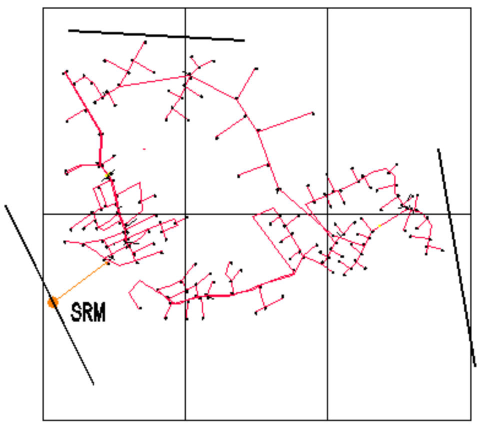


Fig. 6. *Constructive variant 6 of natural gas distribution network*

For example, we selected a branch network with the following characteristics [2]:

- Diameter: d=160 mm
- Lenth: L=0.200 km

Minimum outlet pressure: $P_{min,outlet}$ =1.25 bar.

Figure 7 shows the variation of maximum flow transported through the pipeline, for various values of inlet pressure.

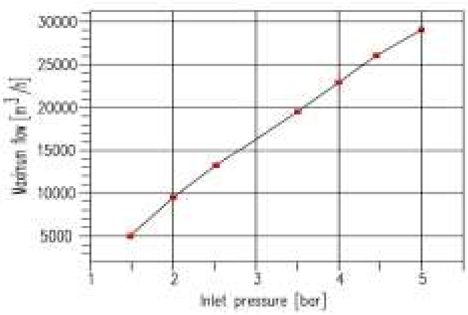


Fig. 7. *The maximum flow variation depending on the inlet pressure*

To illustrate the solution of amending the diameter we selected a branch network with the following characteristics:

- Flow rate: Q=4000 m^3/h
- Lenth: L=0.200 km

Minimum outlet pressure: $P_{min,outlet}$ =1.25 bar.

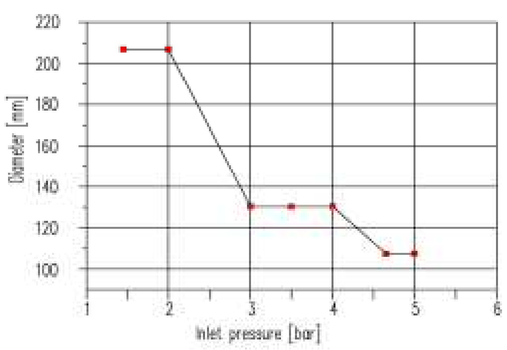


Fig. 8. *The diameter variation depending on the inlet pressure*

There is a decrease in the diameter steps from the pressure of 3 bar. Further increase of pressure causes a decrease in the diameter only at the value of 4.5 bar.

3. Results and Conclusions

The problem of optimizing the distribution networks of natural gas is of current interest due the increasing consumption in congested urban areas where the capacity of the current distribution networks is exceeded. Also, in the new residential neighborhoods the networks should, from the beginning, be dimensioned in order to allow further expansion with great flexibility.

Technical efficiency is a component of economic efficiency and represents the increase of the useful effect produced by the consumption of material resources and working force.

Energetic efficiency is a component of the technical efficiency which represents an increase of the useful effect obtained by the consumption of a form of energy in order to produce a final good or deliver a service to a final consumer.

The reported income updated per costs (R) is calculated with the following formula:

$$R = \frac{\left[\dfrac{\sum_{h=1}^{d+D} Vh}{(1+a)^h}\right]}{\dfrac{\sum_{h=1}^{d+D}(I_h + Ch_h)}{(1+a)^h}} \geq 1 \qquad (1)$$

in which:

V^h - represents the total annual income

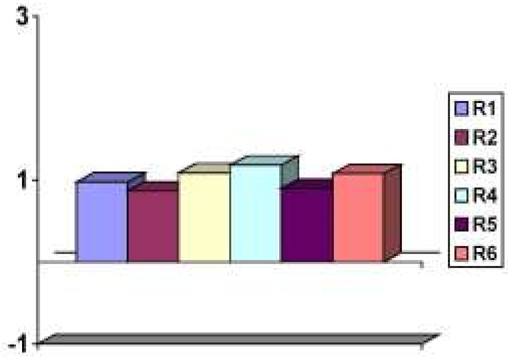
Ch^h - annual costs of production

I^h - annual investment

In constructive variants no. 1, 2 and 5 the project is not efficient: the total annual costs are not covered by income.

The constructive variants no. 3, 4 and 6 are efficient. From the graph (Fig. 9) it can be seen that the most efficient is variant 6: ring network with a single supply point, output station adjustment-measurement, medium pressure of 5.0 bar.

A graph comparing the reports for the six alternatives is the following:



R1 to R6 – reported income updated per costs for variant 1 to 6

Fig. 9. *Reported income updated per costs*

It can be seen that the variant 4 is slightly higher if we take into account only the economic efficiency. It is therefore interesting to evaluate and compare the energetic efficiency of the six variants studied.

4. Acknowledgment

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