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Application of soft computing to research of transient processes in the gas pipelines

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Abstract

The article considers the issues of applying the methodology of "soft computing" to analyze transients in gas pipelines. The gas pipelines have to operate in the transient regime before an exit to new steady-state flow regime. A set of values for the pressure of gas within the interval of output at the new steady-state flow regime was considered as fuzzy set, when with sufficient accuracy can only be determined values for the gas pressure to shut-down and after the new flow regime. On the basis of the computational experiments was obtained time series for changes in the basic parameters of the gas stream and constructed the corresponding curves. These curves were processed by methods of fractal geometry and the basic laws of their behavior. An effective apparatus to diagnose structural changes of the gas flow in case of emergency situations in gas pipelines is developed. The results of these studies can be recommended for use by services operating gas pipelines.

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Keywords: gas pipeline; transient rejims; fuzzy set; fractal measure.

1. Introduction

The various processes occurring in system of pipeline transport of gas, are characterized by that engineering decisions on management of these processes are accepted often in the conditions of uncertain or not enough the exact information. So, for example, the operating mode of the main pipelines (a mode of pressure of gas) is influenced by various random factors, such as air temperature, non-uniform selection of gas by consumers and

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other factors. If to take into consideration, that such important parameter as the friction factor, is estimated depending on flow regime and a pipe roughness. The correct estimation of this parameter it is not possible.

At the same time, the main gas pipelines at switching-off or, on the contrary, at start-up of compressor units operates in transient modes which make uncertainty and unpredictability to dynamics of flow parameters. In the main gas pipelines it is possible to present transient modes as change of conditions which correspond to a certain combination of values of the basic flow parameters (pressure, flow rate expense, temperature).

2. Statement of the problem and its solution

Let's consider the following technological situation in the main gas pipeline. The gas pipeline is in a condition 1 (the established mode, pressure of gas P_1). There is a sudden switching-off one or several compressor units. After a while the system exits in a new condition (condition 2, the new established mode, gas pressure P_2). With certain degree of accuracy it is possible to calculate values of pressure P_1 and P_2. Itself transient process from one established mode (a condition 1) in the new established operating mode (the condition 2) owing to the nonequilibrium and non-stationary phenomena has, generally speaking, stochastic character. In a transient mode between these two conditions, it is possible to receive a picture of change of pressure of gas generating of random numbers on the interval (0,1). Value «0» corresponds to condition P_1, and value «1» - to a condition 2. The set of conditions between P_1 and P_2 in that case can be define as fuzzy set, where each of values has a corresponding membership measure by Zadeh (1965).

In such statement of a problem at operation under transient modes (we will marked this set PR) it is possible to present fuzzy set of values of pressure as set of next pairs:

$$PR = \{(p, \mu(p)|p \in P\} ,$$

p- elements of set of values of pressure P from a interval $[P_1, P_2]$; μ (p) - the corresponding membership function defining a membership measure of the given element of set PR.

Thus, for definition of dynamics of transient modes in the main gas pipeline instead of difficult calculations («hard computing»), we carried out «soft computing», the most suitable to character of change of a pressure between two established modes. This approach by our reason is the most comprehensible to modeling of transient processes in the main gas pipelines.

With other positions, before occurrence of a supernumerary situation in the main gas pipeline (for example, sudden switching-off of compressor units) it is possible to imagine the established mode of a current as the certain ordered structure. The transient subsequent to it is brought in this orderliness by some indignation and system after a while exits on the new established mode of a current. Thus, in a considered technological situation it is possible to present an operating mode of the main gas pipeline as the following change of conditions of a gas stream: the ordered structure before switching-off → transient disorder structure → the new ordered structure.

Concepts «the ordered structure» and «disorder structure» have conditional character and have no accurate borders. It is possible to say only about a measure of orderliness (disorder), that in turn it is well enough estimated by methods of fractal analysis as shown by Ismailov et all (2005). On change of Hausdorff's measure by «soft computing», avoiding difficult calculations it is obviously possible to investigate transient processes in the main gas pipelines.

Proceeding from the aforesaid, the following technological situation in the main gas pipeline has been simulated. There is a sudden stop one or several compressor units. The gas pipeline starts to operate in a transient mode and through certain time the gas pipeline exits on the new established mode. As dynamics of change of gas density within an exit on the new established mode as it has been proved above, has casual character generating of random numbers had been received values for gas density.

Computing experiments were made at next initial data: initial pressure about 1,8 MPa; pressure drop about 0,1 MPa; 0,3 MPa and 1 MPa. Results of the experiments are presented on figures 1 - 3.

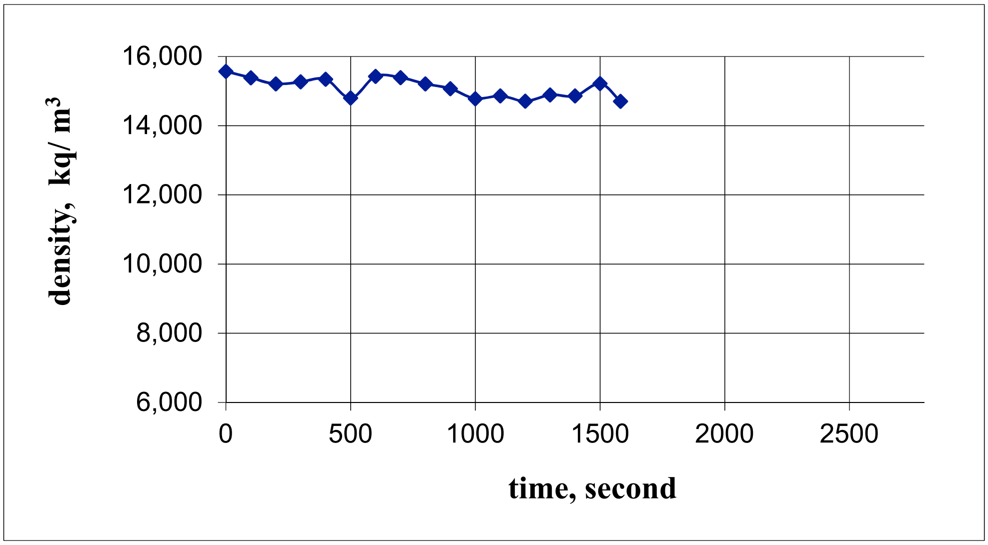

Figure 1 Dynamics of gas density under pressure drop 0,1 MPa

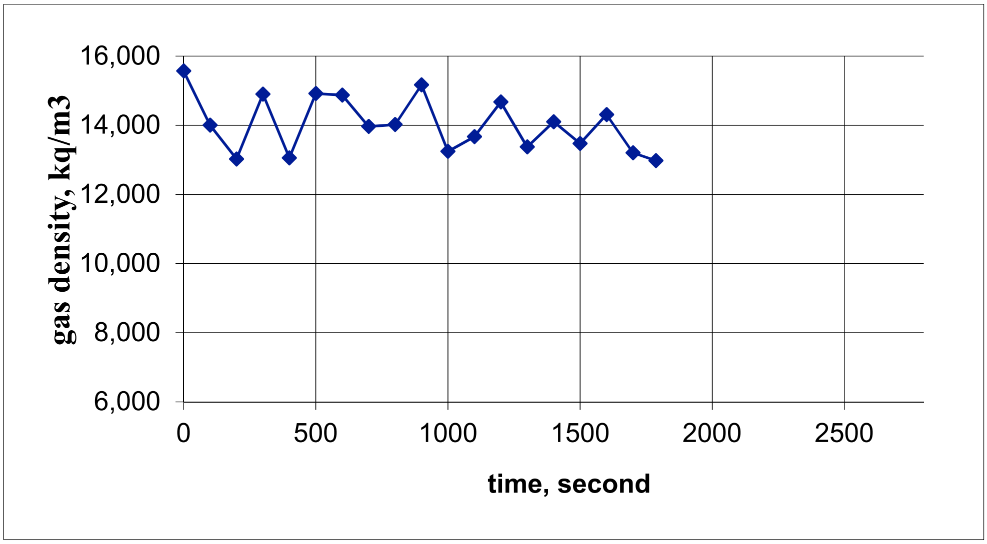

Figure 2 Dynamics of gas density under pressure drop 0,3 MPa

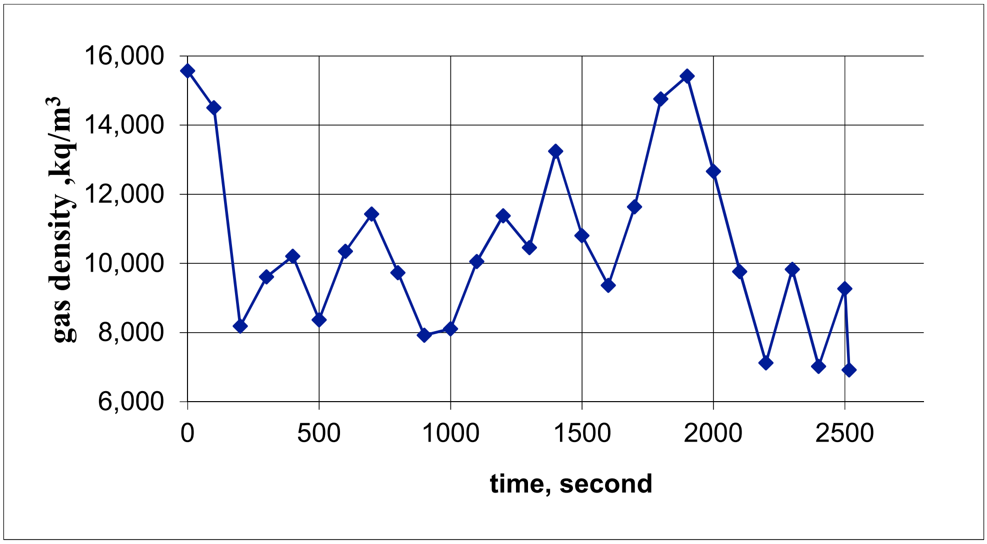

Figure 3 Dynamics of gas density under pressure drop 1 MPa

Further by a technique of Feder (1991) have been calculated Hausdorff's fractal measures for all drawn curves as shown by Sattarov (2006).

For the purpose of evident representation of change of fractal measure depending on pressure drop the corresponding curve is drawn on figure 4.

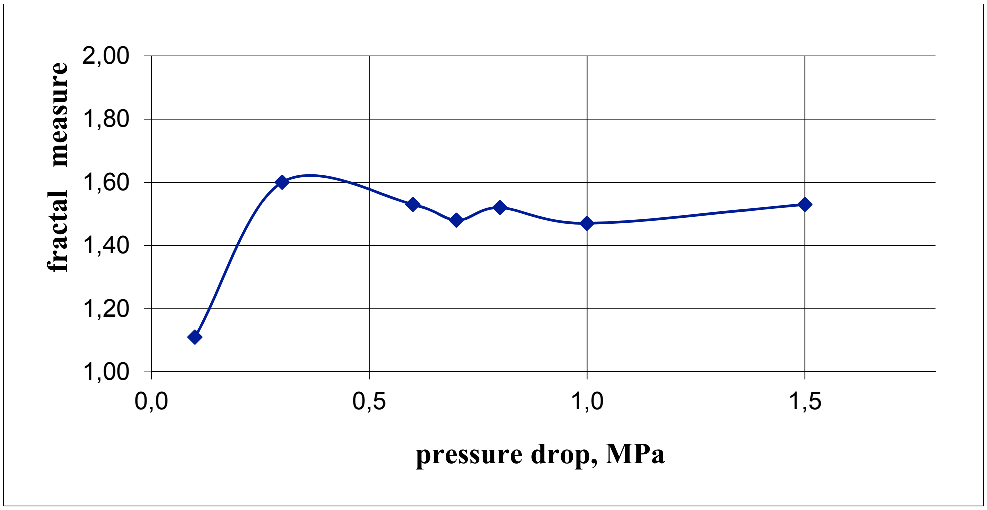

Figure 4 Dynamics of fractal measure depending on pressure drop

As can be seen from the figure, since the value 0,3MPa further increase the pressure drop in quality is not reflected in the change of the fractal measures and corresponding values for fractal measure remain almost at invariable level.

3. Conclusion

Thus, as have shown results of the fractal properties of natural gases start to prove at transients in the main gas pipelines, since certain pressure drop, but the fractal measure do not depend essentially on pressure drop. That is essential jump in change of fractal measure (from 1,1 for pressure drop 0,1 MPA to 1,60 for 0,6 MPa) and the further alignment of the corresponding curve is characteristic for transient modes in the main gas pipelines.

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