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Teză de doctorat

CERCETĂRI PRIVIND PROCESELE TERMO ȘI HIDRODINAMICE DIN CONDUCTELE MAGISTRALE DE TRANSPORT GAZE NATURALE

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The researches related to the thermal and hydrodynamic processes from the main pipelines of natural gas transport

The motion of gas through the transport pipelines is affected by the thermal interaction of the soil through which they are buried. The thermo and hydrodynamic phenomenon that accompany the gas motion leave their mark on the heat exchange between those and the cooler soil (according to the depth of burial).

The mechanism of the thermal transfer makes the temperature of the interior wall of the pipeline varies all along the pipe changing with that all the hydrodynamic parameters. As result the variation of the pressure will differ from the corresponding to acceptance of the isothermal motion hypothesis. In addition the affect of Joule - Thomson specific for the gas expansion will lead to additional decrease of the gas temperature which affects the hydrodynamic parameters.

The increased consumption of the gas in a rapid rate, both to meet the need of fuel and as raw material in petrochemical industries requires review how to tackle the problem of designing and operating the pipelines of gas transport from the reservoir to the consumer.

Generally, regardless the area of the consumption the necessities of gas continuously increase from one year to another, after a dynamic more or less known in perspective. Resulting that the gas transportation capacity of the main pipelines, which feed that area of consumption, must be changed over time, in order to be able to cope with the evolution of the flow required.

Therefore, the study of the non stationary phenomenon that accompany the gas flow through the main pipeline, presents a great practical importance., for solving the set of problems related to the peak of consumption.

First of all we refer to the reserves accumulated in the pipelines in the minimum consumption period, generally, the main pipelines of gas have great lengths of hundreds of kilometers and diameters that reach to one meter, some even exceed one meter. So, they have big geometric sizes and can be considered reservoirs, from which can ensure gas feeding during the peak hours of a day.

It is known the fact that the pipeline is fed with gas through the initial head, which delivers gas to the consumers, through the other head, the final, to meet the variable flow of the consumers, if the pressure in the final head will not go below the minimum admissible

value imposed by the functioning of the measurement and control equipments of the distribution network.

Likewise, the functioning of the intermediate compressor stations produces important disturbances in the operation of the main pipeline of gas, while the time after the gas flow regime re-stabilization has very big importance for the efficiency of that maneuver.

Mathematical modeling of the non stationary phenomenon that accompany the gas flow through the main pipelines leads to a series of differential equations of second order nonlinear. The mathematical difficulties, encountered until now to find solutions for the equations that model the non stationary phenomenon, made that those pipelines are designed in stationary flow hypothesis, increasing abusively the diameter of the pipelines to meet flow variation leading in this way to un justified efforts and investments or to difficulties in meeting the necessities of consumption.

So, resulting that both, rational operation of the existed pipelines and judicious designing of future pipelines, must be based on profound study of gas flow in non stationary regime.

This paper is part of this area of research and presents a series of results of mathematic modeling of thermo and hydrodynamic phenomenon that accompany the gas flow through the main pipelines. The results obtained were checked by measurements in site, performed on main pipeline provided with a compression station. The simulation of operation of that pipeline based on computer programs presented for this scope has revealed both the correctness of the mathematic models and the utility of those in practical operation. In addition, taking in to consideration the multitude of factors involved in gas pipeline design calculation, we believe that this is greatest area of utility of the work.

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The thesis is structured in two parts, in the first part were presented the theoretical aspects involved in studying the thermo-hydrodynamic phenomenon that accompany gas motion through the transportation pipeline. It is about the results obtained by my predecessors with the help of some models that are the basis of the thesis.

Thereby, in Chapter 1, entitled **The properties of natural gas involved in the transportation process** were presented the principle properties of natural gas that condition the thermal and hydrodynamic aspects of transport. The problem of gas humidity with its implication especially in flow measurements was also presented. Likewise, the mechanism of cryohydrates appearance in the transportation pipeline and methods to prevent their formation is presented too.

In chapter 2, entitled **Stationary flow of gas through the pipeline** is presented the classic model of the stationary flow, also the numeric approach of this model, starting from the observation refer to its imperfection. I was able to perfect it in the way presented in chapter 4, part II of the thesis.

In chapter 3, entitled **Non stationary flow of gas through the pipeline** are presented the methods of approach of non stationary flow, respectively two mathematic methods considered significant, the *disturbance and integral transformation* method, for which I presented its application in case of some simplified models that can be used in gas transport via main pipeline simulation. I presented also the approximate numeric calculation method through finite differences method. Further I introduce the mathematic modeling of those two types of rapid flow characteristic slow variation of these parameters.

In the second part the personnel contributions are presented, i.e. the results obtained within the thesis elaboration.

In chapter 4, entitled **study of stationary motion of gas in main pipeline** was treated the problem related to the thermal and hydrodynamic phenomenon from gas pipeline, a work of great importance in practice, starting from gas motion equations in stationary regime hypotheses reaching to a mathematic model that takes into account all gas dynamic parameters involved. Resolving the equation system that comprises the model was performed by numerical integration method Runge – Kutta of order 4.

The developed model was materialized through a calculation program that was validated based on experimental measurements on a pipeline of natural gas transportation from Romanian system of transport.

In chapter 5, entitled **study of transient regimes that appear in gas main pipeline operation** was treated the problem related to hydrodynamic phenomenon from transportation pipeline generated by variation of the principal hydrodynamic parameters, flow and pressure. This chapter materializes the principal results of the research. The conceptions of on which the modeling of transitional regime from main gas pipeline generated are presented in an original manner, respectively the pressure variation from the entering the pipeline. The numeric approaches, although it is inspired from predecessor researches, they are original, while the programs and software developed for the purposes of different operations situation simulation – validated by experimental measurements, are very useful and easy to use by the operators of natural gas transportation regimes.

In chapter 6, entitled **study of hydrodynamic process of sub fusion of soil that appears to malfunction of main pipeline of natural gas** was treated the problem related to a process that appears in the defected areas of the main pipeline of gas.

Defect formation on a main pipeline of gas transportation leads to appearance of losses that depend on the hydrodynamic parameters of the pipeline and the characteristics of topsoil adjacent defect. At a certain speed of flow the sub fusion phenomenon is produced, that requires the expulsion of the granulated material towards the soil surface. In the thesis is presented the mathematical modeling of soil sub fusion process, taking into account both the hydrodynamic aspects of the phenomenon and the properties of the porous medium in the area of pipeline burial. The validation of proposed model of sub fusion in the thesis was performed by experimental realization of such processing of case study. The error of 4.2% on the geometry of sub fusion area can be considered satisfactory.

In chapter 7, entitled **study and design of main pipeline of natural gas Acaz (Iraq) – Homs (Syria)** is treated the problem related the concept of a main gas pipeline that takes Acaz reservoir production from Iraq and transport it to Homs, Syria, where passes a main gas pipeline from Egypt towards Turkey.

In study presentation was taking into account the production capacity of the reservoir, the approximate rout of the pipeline and the pressure regime imposed by the transportation of about 400 km distance.

In the final part, were presented the conclusions drawn from the performed researches within the thesis, as well as the author contribution in solving the thesis problems.

The consulted bibliography contains 84 bibliographic references, Romanian and foreigner authors. Out of those 4 are articles to be published in quality of first author by the bulletin of the University of Oil and Gas, Ploiesti, technical series, that are disseminated the principal results of the research performed by the author, while another 4 are scientific works presented within the doctorate program.