INFORMATION RESOURCE AND ENERGY-SAVING TECHNOLOGIES OF THE CONTROL OF PIPELINE SYSTEMS

Dyadun S.V.

V.N.Karazin Kharkiv National University, Ukraine.

E-mail: s.v.dyadun@karazin.ua

Abstract

The report presents the structure of the solution of the whole complex of operational control tasks by functioning of real pipeline systems from problem statement to their practical implementation. Analyzes a wide range of issues arising in the research, development, and implementation of mathematical models, methods, algorithms, and software systems for solving both individual problems and the practical implementation of operational control systems for pipeline systems as a whole, within subsystems of automatized pipeline control systems. The use and widespread introduction of information technologies of optimal control of functioning of pipeline systems allows in practice to improve the quality and effectiveness of their work by reducing the excess pressure in the networks (and, consequently, reduce unproductive costs of the target product), reducing electricity costs on pump stations, reducing the probability of accidents on the networks.

The report consider the creation and development problems of resource- and energy-saving information technologies for operational control of pipeline systems (water supply, gas, heat, and wastewater systems). Presents the structure of the solution of the whole complex of operational control tasks by functioning of pipeline systems from problem statement to their practical implementation.

Solution of operational control tasks flow distribution in pipeline systems at every stage - program control and stabilization - usually separated in time and space, requires a different amount of the composition and the nature of intelligence, different mathematical models describing the object of control, criteria and methods of solution control problems. At the same time, the implementation of each stage of control is ensured by solving a specific set of tasks. These tasks can be divided into modeling tasks performed outside the contour of the real control and directly control problems solved online. In the real conditions of functioning of pipeline system certain parameters (for example, expenditure on consumers and on the network) is not possible to measure and sensors by means of which measure parameters characterizing the state of pipeline system, not always possible to set in necessary points of the network by technological reasons. In addition, the information obtained is unreliable due to measurement errors and noise in communication channels. All this imposes certain requirements for the selection of the model of the control object. To solve the program control tasks of the operation of pipeline systems an adequate mathematical model of the object can be obtained in a class of models of steady flow distribution. To solve the problems of stabilization modes using dynamic models. The model steady flow distribution contents information about network topology and technological parameters of all elements of the equivalent circuit of pipeline system. The incompleteness and unreliability of the initial operational and technological information, time restrictions on solutions software control tasks, requirements for the saving costs in technical equipment for necessary gathering of information, technological reasons related to the failure to establish the control sensors in necessary points in the network are responsible for the need to develop suitable models for purposes of operational control at pipeline system. Used mathematical model of pipeline system must have acceptable accuracy repeatable processes in comparison with the real object of control and should not make a significant error in the control of the functioning of the real pipeline system [1]. Refinement of the model structure and estimation her parameters are carried out at the stage of identification of the model. Adequate model is used to solve the software control tasks. If the model is not adequate, are diagnosed the reasons for this, and she returns to the stage of identification of its structure or parameters. Thus obtained model is the basis for the construction of the pipeline systems optimal control algorithm. The most important tasks in constructing pipeline system models in terms of their impact on the effectiveness of implemented control are: identifying the parameters of pumping station units of pipeline systems; identifying the structure of the pipeline system model graph; identifying the parameters of pipeline system model sections; identifying the structure of the target product consumption processes model; identifying the parameters of the target product consumption processes; identifying the parameters of transfer functions linking pressure values at pump station outlets with pressures at dictating points in pipeline systems (the stabilization stage).

The solution of these tasks precedes for the organization of the functioning of the process operational flow distribution control in pipeline systems. The listed tasks of constructing models of pipeline systems and the environment are also solved periodically, but with a significantly longer period, and also as needed, in connection with the introduction of new or replacement of old elements that form the pipeline system. Pipeline systems have specific properties related to the presence of dictating points. Dictating point of the pipeline system in time is a point in which the excess pressure in the same moment of time is minimal. The quality of the functioning of pipeline system can be characterized by her state in dictating points. The stochastic nature of the desired product consumption process is a continuous change in flow distribution in the network and the emergence of a set of dictating points. The use of these properties allows the synthesis of a control system that would ensure the specified quality of the pipeline system operation in dictating points.

Solution of operational control tasks flow distribution in the pipeline system is achieved by solving sequence hierarchically interrelated tasks. Let us consider in more detail the structure of the solution of operational control tasks operation of the pipeline system. On the basis of the operational information obtained by the simultaneous interrogation of sensors installed in the monitored network points, it solves the problem of identifying of the state of pipeline system. Multiple solution of this problem to determine for each node of the model of pipeline system vector estimated costs in the future be used as a set for the forecast expenditure values in each of these nodes for the entire control range. Solution nodal values expenditures forecasting tasks for a given time interval is an input information directly to the software control task of pipeline system modes of functioning, the decision of which is determined by solving the task sequence. First, for each of the discrete points in time k = 1,2, ..., k solve the problem of optimal distribution of load between pump stations during their joint work on pipeline system. As a result of its decision to all k = 1,2, ..., k are determined by the value of costs and pressures on the outputs of pump stations, providing pressure in the nodes is not specified below. For the parameters obtained at the outputs of the pump stations as a result of decisions for all k = 1,2, ..., k the problem of optimizing of the mode of pump stations, for each of them determined the optimal structure and parameters of its functioning. However, obtained at the stage of program control decision should be invariant with respect to the projected level of environmental perturbation stochastic environment. In order to study its efficacy in the prior stochastic perturbation solve the problem of load flow analysis in the implementation in the pipeline system on the model of control actions on pump stations. This objective is based on a mathematical model of steady flow distribution in the pipeline system with active elements. This sequence of solutions software control tasks allows you to get an invariant with respect to the projected level of stochastic perturbation solution which guarantees the necessary quality of the functioning of pipeline system at all control range $[0,T]$ at maximum efficiency. Stabilization pressures in dictating points of pipeline systems partially compensates for the disturbance affecting the object of control in order to prevent the output mode parameters beyond the permitted area.

Presented the structure of the solution of the whole complex of operational control tasks by functioning of real pipeline systems from problem statement to their practical implementation. The use and widespread introduction of information technologies of optimal control of functioning of pipeline systems allows in practice to improve the quality and effectiveness of their work by reducing the excess pressure in the networks (and, consequently, reduce unproductive costs of the expected product), reducing electricity costs on pump stations, reducing the probability of accidents on the networks.

References

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