Abstract

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« DEVELOPMENT OF METHODS FOR CONTROL OF THE SOFTWARE ENVIRONMENT IN AUTOMATED CONTROL SYSTEMS FOR TECHNOLOGICAL PROCESSES»

Relevance of the research topic. In integrated automated control systems (IACS), the lower level is responsible for direct control of technological processes and generation of operational information on production status. At this level, an Automated Control System for Technological Processes (ACS TP) operates, in which the dispatcher subsystem is implemented using SCADA systems. SCADA systems provide monitoring of technological process states, parameter visualization, data registration and archiving, event processing, and command transmission to equipment control levels.

Correct operation of SCADA systems is largely determined by the consistency of the software environment of the dispatcher level of ACS TP and the nature of interaction between its components. Violations in the software environment operation lead to distortion of the technological process information model, increased response time to deviations, reduced efficiency of operator control, and the formation of conditions that increase technological and information risks.

The actual configuration of the software environment is defined by the composition of software components, their versions, configuration parameters, and inter-component interaction conditions. Long-term system operation is associated with destabilizing factors caused by hardware failures, operational interventions, and latent software defects. Under the influence of these factors, deviations of the actual software environment parameters from the normative configuration description may occur while maintaining apparent system operability.

Operational maintenance of the software environment is primarily focused on ensuring system operability and monitoring functional and operational indicators observed during exploitation. These procedures are generally aimed at confirming the execution of specified functions and do not involve regular detailed comparison of the actual software configuration with its normative description. As a result, individual configuration inconsistencies that do not manifest at the functional level may persist during early operation stages and be detected only after further degradation, leading to increased diagnostic uncertainty and higher recovery effort.

These circumstances determine the relevance of the scientific and technical task of developing methods for formalized organization and automation of

maintenance of the software environment of the dispatcher level of ACS TP. The proposed solutions are focused on controlling the compliance of the actual configuration with the normative description during operation, increasing the efficiency of maintenance procedures and reducing the labor intensity of control and diagnostic operations.

Object of research: the architecture and organization of the software environment of the dispatcher level of Automated Control Systems for Technological Processes.

Subject of research: processes of formation, modification, and maintenance of the configuration of the software environment of the dispatcher level of ACS TP during operation.

The aim of the work is to develop methods for automated maintenance and control of the software environment configuration of the dispatcher level of ACS TP, ensuring its compliance with the normative configuration description during industrial operation.

The research **tasks** include:

1. Formulation and justification of the problem of software environment configuration control of the dispatcher level of ACS TP under industrial operation conditions.
2. Development of a model for formalized representation of the actual configuration of the ACS TP dispatcher software environment based on operationally accessible data, suitable for comparison with the normative configuration description.
3. Development of automated configuration control methods for the ACS TP software environment that ensure detection of configuration deviations, generation of corrective actions, and maintenance of the normative configuration during operation within regulated maintenance procedures.
4. Development of an automated maintenance system for the software environment of the dispatcher level of ACS TP, providing practical implementation of the developed models and methods and their integration into industrial operation processes.
5. Experimental verification of the developed methods and maintenance system on an industrial ACS TP dispatcher software environment of a water intake facility.
6. Quantitative evaluation of the effectiveness of the software environment maintenance system by comparing the labor intensity of maintenance procedures before and after its implementation.

Research methods. The study is based on methods of systems analysis and algorithmic modeling. Elements of set theory are used for formalized representation of the software environment configuration and its change processes. Structural-functional and architectural analysis methods are applied to analyze the composition of the software environment and interactions between its components. Experimental methods are used to verify the developed solutions under industrial operating conditions.

Scientific novelty:

1. A model for formalized representation of the configuration of the dispatcher-level ACS TP software environment has been developed, oriented toward operational maintenance tasks and ensuring comparability of actual and normative configurations through unified parametric representation.
2. Configuration control models for the ACS TP software environment have been developed, including a model for generating regulated corrective actions based on comparison of actual and normative configurations and a model for their execution under operational conditions.
3. Automated maintenance methods for the dispatcher-level ACS TP software environment have been developed, based on formalized configuration descriptions of software components and configuration control models, ensuring consistency of component composition and parameters during operation.
4. A method for architectural organization of centralized maintenance of the ACS TP software environment has been developed, based on allocation of maintenance functions into a specialized contour functionally independent from application software components.

Theoretical significance:

The work develops theoretical foundations for construction and maintenance of software environments of Automated Control Systems for Technological Processes. The formulated and substantiated theoretical provisions aimed at formalization of software environment configuration representation and processes of its maintenance and restoration during operation expand the theoretical basis for designing architectures and maintenance organization of complex software systems for industrial automation.

Practical significance:

The developed methods and software system can be applied during operation of dispatcher-level ACS TP software environments to perform formalized control of configuration states. Implementation of the proposed solutions ensures automated detection of configuration deviations, generation of corrective action plans, and support of recovery procedures for normative configuration under regulated operating conditions. This reduces labor intensity of control, diagnostic, and

recovery operations and decreases the risk of accumulation of latent configuration inconsistencies, thereby improving operational reliability of ACS TP software environments.

The main provisions for the defense:

1. A formalized representation of the configuration of the dispatcher-level ACS TP software environment, including description of software component composition and parameters.
2. Imperative and declarative methods for bringing the ACS TP software environment configuration to a specified representation, differing in principles of corrective action generation and execution.
3. Architectural organization of a centralized maintenance contour for the ACS TP software environment, providing centralized execution of maintenance procedures.
4. A method for automated maintenance of the dispatcher-level ACS TP software environment based on formalized configuration descriptions of software components.
5. A software system for maintenance of the ACS TP software environment implementing formalized methods for configuration control, restoration, and maintenance.