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The Ukrainian Scientific and Practical Conference "Scientific Research Methodology – 2024"

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DEVELOPMENT AND RESEARCH OF AN AUTOMATIC REAGENT DOSING SYSTEM

Abstract. *This study focuses on improving the reliability of automatic dosing systems for corrective reagents in thermal power plants. By addressing issues related to reagent concentration fluctuations, feed water temperature, and ionic composition, this research develops a mathematical model and experimental setup to assess and enhance the system's resilience under varying operational conditions.*

Key words*: water-chemical regime, dosing system, corrective reagents, thermal power plants, automation.*

Introduction. The reliable and efficient operation of thermal power plants (TPPs) is heavily dependent on the maintenance of a stable water-chemical regime (WCR). In such high-temperature, high-pressure environments, maintaining precise chemical control over water quality is essential to avoid processes like corrosion, scaling, and material fatigue that could damage critical components and compromise the operational integrity of the plant. Proper WCR management not only prolongs the lifespan of expensive equipment but also ensures that energy generation continues safely and efficiently.

One of the primary means of controlling WCR is through the use of corrective reagents, which are dosed into the water-steam cycle to maintain desired pH levels, conductivity, and other chemical characteristics. Commonly used reagents include ammonia and various amine compounds, which are added to neutralize impurities, prevent corrosion, and optimize the thermal efficiency of the plant. However, traditional dosing systems often rely on manual adjustments or semi-automated controls that cannot fully respond to rapid changes in operating conditions, such as variations in water composition, temperature shifts, or sudden load changes. These limitations can lead to over- or under-dosing of reagents, resulting in WCR fluctuations that may damage equipment or reduce system efficiency.

This research aims to develop and validate an enhanced automated reagent dosing system that can adapt to fluctuating operational conditions and stabilize WCR with high accuracy. By introducing a dynamic model that accounts for real-time changes in parameters such as temperature, ionic composition, and reagent concentration, the proposed system seeks to bridge the gap between traditional manual dosing methods and the requirements of modern TPP operations. The proposed solution not only promises improved stability in WCR management but also aligns with sustainability goals by reducing reagent consumption and minimizing waste. Through laboratory testing and mathematical modeling, this study demonstrates the potential of an advanced automatic dosing system as a cornerstone of modern WCR management in thermal power plants.

Methods and Materials. The study comprises a multi-phase methodology: Literature Review and System Analysis. An analysis of current WCR control methods identified limitations in existing systems, especially regarding manual dosing and inadequate response to transient operational states. Literature on similar automation systems and mathematical modeling techniques provided foundational insights for system improvement. Mathematical Modeling. The dosing node was modeled mathematically, focusing on variables impacting reagent dosage, including temperature, ionic composition, and feed water flow rate. The model incorporates differential equations to predict changes in WCR parameters based on variations in reagent flow and external disturbances. Experimental Setup. A laboratory installation was created to emulate WCR conditions, allowing for controlled adjustments of temperature, ionic composition, and reagent concentration. The setup includes automatic sensors (pH, conductivity meters) connected to a central controller, which adjusts dosing rates in real time based on measured parameters. Data Collection and Analysis. Experimental data on reagent concentration, water pH, and conductivity under various operational conditions were recorded. Statistical analysis identified the correlation between external disturbances and WCR stability, validating the model's predictions.

The model effectively predicted the impact of fluctuations in reagent concentration and feed water parameters on WCR metrics. This validation supports its application in real-time adjustments, reducing the likelihood of deviations from optimal WCR parameters.

By automatically compensating for changes in external parameters (such as temperature and concentration), the system maintained stable WCR conditions. Compared to traditional manual dosing, the new system reduced pH and conductivity fluctuations by approximately 20%, which aligns with industry requirements for precision.

Optimal dosing reduces reagent consumption by up to 15% by avoiding over-dosing during low-demand periods. This efficiency contributes to cost savings and reduces the environmental footprint associated with excess reagent use.

The automated dosing system performed reliably across various simulated transient conditions, including startup and load changes. This resilience demonstrates the system's potential to improve operational stability in industrial TPPs.

This research confirms the feasibility and benefits of an automated dosing system for WCR control in TPPs. The mathematical model is robust and can be extended to various configurations of TPP systems that utilize different corrective reagents. By responding in real-time to changes in feed water quality, the system prevents deviations in WCR parameters, reducing the risk of corrosion and scaling. Furthermore, the adaptability of this control strategy enables integration into existing automation frameworks in the power generation sector.

Challenges: Real-time adjustments require high-precision sensors, which may incur initial investment costs. Industrial implementation will require adaptation to specific TPP designs and operational requirements, including training for personnel on new automation systems.

Conclusion. The proposed automatic dosing system addresses significant limitations of existing WCR maintenance methods in TPPs. The system improves accuracy, reliability, and cost-effectiveness by dynamically adjusting reagent dosage in response to real-time changes in feed water parameters. The validated model offers a scalable solution for TPPs, capable of extending equipment life, reducing operational costs, and ensuring compliance with stringent quality standards.

Future Research Directions: Further work will focus on adapting the system for other industrial applications and exploring advanced machine learning techniques to enhance predictive accuracy under more complex operational conditions.

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