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# Realtime Thermal Power Plant Feedwater Chemistry Control Using Artificial Intelligence

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***Abstract:** This paper presents an enhanced, publication-ready version of the original work on AI-driven real-time control of boiler feedwater chemistry. Feedwater chemistry control is critical for ensuring reliable and efficient thermal power plant operation. Traditional practices rely heavily on fixed dosing, delayed manual actions, and limited parameter interactions. These methods often fall short under transient operating conditions. This paper introduces a robust AI framework capable of forecasting short-term chemistry variations and optimizing chemical dosing, resulting in improved stability, reduced chemical consumption, and proactive corrosion prevention.*
***Keywords:** Boiler feedwater chemistry; power cycle chemistry; artificial intelligence; machine learning; predictive chemistry control; thermal power plants; corrosion mitigation.*

## I. INTRODUCTION

Boiler feedwater chemistry significantly influences power plant performance, reliability, and equipment life. Inadequate chemistry control can lead to rapid corrosion, deposit formation, and silica transport—causing major operational and safety issues. Although online analyzers have improved over time, many plants still employ reactive chemistry control, where interventions occur only after deviations are detected. With modern plants increasingly operating in cycling mode and using variable-quality makeup water, predictive and adaptive chemistry control has become essential.

## II. LIMITATIONS OF CONVENTIONAL CHEMISTRY CONTROL PRACTICES

Conventional feedwater chemistry control relies on periodic sampling, fixed chemical dosing, and manual operator judgment. Such approaches have several limitations:

1) Slow response to rapid chemistry fluctuations during transients.
2) Inability to capture interactions among multiple chemistry parameters.
3) High dependency on operator expertise.
4) Increased excursions during startups, shutdowns, and load changes.

These limitations elevate the risk of accelerated corrosion and conductivity excursions, leading to higher maintenance and operational challenges.

## III. CONCEPT OF AI-BASED REAL-TIME CHEMISTRY CONTROL

The proposed AI-based system functions as an intelligent decision-support layer, complementing existing distributed control systems (DCS). The system predicts near-term variations in key chemistry parameters and recommends adaptive dosing actions in real time.

The framework includes:

1) Real-time acquisition of analyzer data.
2) Machine-learning-based prediction models.
3) AI-assisted dosing control logic.

This creates a semi-autonomous closed-loop chemistry control mechanism.

## IV. DATA INPUTS AND MODEL DEVELOPMENT

### A. *Input Parameters*

The predictive model uses routinely monitored operational data including pH, cation conductivity, dissolved oxygen, sodium, temperature, pressure, and makeup water flow. Time-based features such as rolling averages and rate-of-change indicators enhance the model’s ability to detect transient behavior.

### *B. Machine Learning Methodology*

Supervised ML algorithms—Random Forest Regression and Gradient Boosting—are used due to their capability to handle nonlinear water chemistry dependencies. The models forecast 5–15-minute-ahead chemistry values. Accuracy is validated using RMSE and MAE across various load conditions.

## V. AI-ASSISTED DOSING STRATEGY

Predictive insights are processed through an intelligent dosing module that recommends incremental dosing adjustments instead of fixed feed rates. Key benefits of this strategy include:

1) Minimization of over-dosing and under-dosing.
2) Faster response during rapid load swings.
3) Reduced frequency of chemistry alarms.
4) Improved compliance with target chemistry ranges.

The system may function as an advisory tool or be integrated for semi-autonomous control.

## VI. PERFORMANCE EVALUATION AND EXPECTED BENEFITS

Simulation studies show marked improvement in feedwater chemistry stability compared to traditional manual control approaches. Key outcomes include:

1) Improved stability of pH and conductivity.
2) Reduction in the duration and severity of excursions.
3) Optimized chemical usage.
4) Enhanced corrosion mitigation.

These advantages contribute to better equipment reliability and reduced lifecycle costs.

## VII. DISCUSSION

AI-based chemistry management represents a shift from reactive to predictive operational philosophy. By considering multiple parameters and their interactions simultaneously, the system offers a more holistic and adaptive control approach. This solution is especially advantageous for cycling plants, variable makeup water conditions, and frequent startup-related corrosion challenges.

## VIII. CONCLUSIONS

This paper presents an advanced AI-enabled strategy for real-time boiler feedwater chemistry control. Through predictive modeling and adaptive dosing, the framework enhances chemical stability, minimizes excursions, and supports proactive corrosion management. Future research will focus on real-plant validation and integrating the system directly into plant DCS for automated operation.

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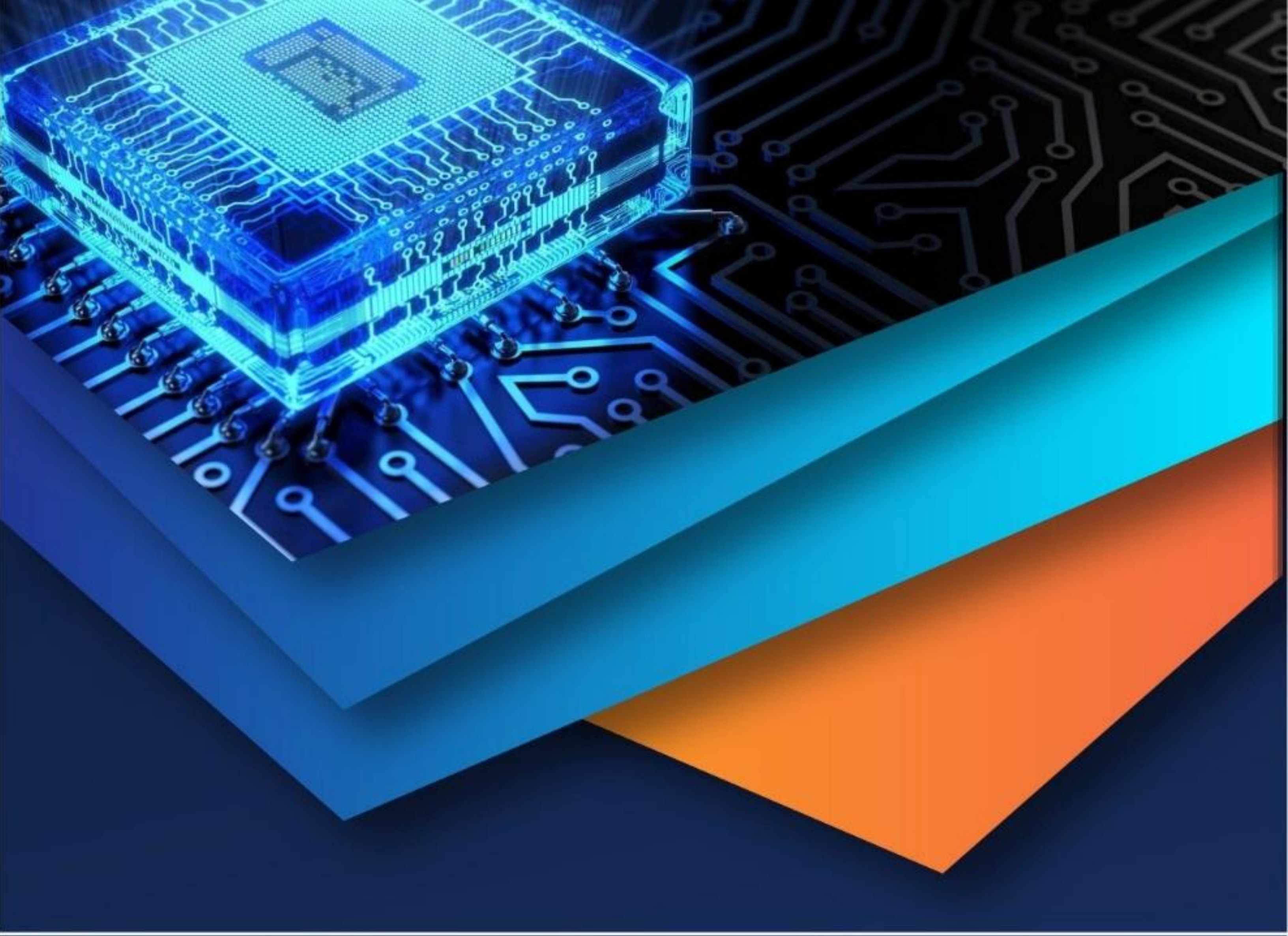

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