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JIIICaS 2024
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"Flourish and Nurturing Sustainable Innovation for a Prosperous Nation"

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Editorial Board

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Preface

In the name of Allah, the Almighty who gives us the enlightenment, the truth, the knowledge and with regards to Prophet Muhammad (peace be upon him) for guiding us to the straight path. We thank to Allah for giving us guidance and strength to write this e-book.

This e-book compiles the extended abstracts that submitted to Johor International Innovation Invention Competition and Symposium 2024 (JIIICaS2024), where JIIICaS2024 is a virtual platform for all creative minds to share and present their invention and innovation. Each abstract gives a brief background on the innovation or project.

We hope that this e-book will help the readers to get to know the innovation done by the students and get some ideas to develop future innovation products.

Foreword Rector

Assalamualaikum warahmatullahi Wabarakatuh, Salam Sejahtera, Salam Malaysia MADANI and Salam UiTM Dihatiku.

In the name of Allah, the Most Gracious, the Most Merciful.

It is a great honor to welcome you to the Johor International Innovation, Invention, Competition, and Symposium 2024 (JIIICaS 2024). This event connects various disciplines, focusing on education and engaging educators, students, researchers, and innovators from all walks of life.

Innovation is not just about ideas; it demands perseverance, creativity, and determination to turn those ideas into reality. The remarkable projects showcased today highlight the dedication and spirit of all participants. Initiatives like this not only explore new technologies but also cultivate skills and leadership among our youth. At Universiti Teknologi MARA (UiTM) Johor Branch, we are fully committed to fostering a dynamic culture of innovation, promoting the commercialization of new products, and encouraging meaningful collaborations with industry and society.

As we celebrate this event, I would like to extend my heartfelt gratitude to all sponsors, judges, the College of Computing, Informatics and Mathematics, UiTM Pasir Gudang Campus as the event organizer, as well as to the researchers and participants for their hard work in making this event a success. Let us continue striving for innovation and excellence. May the ideas presented today inspire us and lay the groundwork for future achievements.

Thank you.

Associate Professor Dr. Saunah Zainon
Rector
Universiti Teknologi MARA (UiTM)
Johor Branch

(A-ST014) OPTIMIZING BOILER SYSTEM EFFICIENCY: A SIMULINK-BASED ANALYSIS OF DRUM AND REHEATER PERFORMANCE

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ABSTRACT

State Space Models represent a cornerstone of innovative problem-solving in the realm of dynamical systems. This study aims to assess the performance of the drum and reheater within a boiler system using Simulink, recognizing the critical need for balanced water flow to avoid detrimental impacts on system compartments. The objectives involve resolving water level regulation issues in the drum and reheater via State Space Models (SSM), integrating Fuzzy State Space Models (FSSM) for precise output parameter estimation, and simulating uncertain model parameters for the drum and reheater. MATLAB programming facilitated data analysis, while Simulink enabled simulation, revealing that both the reheater and drum exhibit similar flow patterns, initially increasing before stabilizing. Consequently, this deeper understanding not only facilitates innovation but also unlocks hidden potentials that theoretical analysis alone cannot uncover. This pioneering approach sets a new standard for innovative problem-solving in boiler system optimization, guaranteeing safety and reliability in operation.

Keywords: SSM, FSSM, Boiler, Drum, Reheater, Simulink

1.0 INTRODUCTION

A State Space Model, an advanced probabilistic graphical model, illustrates the relationship between hidden state variables and observed measurements, encompassing both discrete and continuous data. Pioneered in the 1960s by the field of control engineering, this versatile framework finds extensive applications across disciplines such as engineering, statistics, material science, and control theory, effectively addressing the complexities of dynamical systems. The other type of State Space Model is the Kalman State Space Model. The Kalman State Space Model, or Kalman filter, is widely used in academic research as it approximates dynamic systems. The system uses mathematical equations to show its current state and temporal progression. Control, signal processing, and navigation use the Kalman filter extensively. Moreover, the drum plays a critical role in boiler systems by converting water into steam. It acts as a reservoir, ensuring a consistent water supply to the boiler tubes for steam production. With precision, the drum regulates water levels, ensuring only dry steam enters the superheater for optimal heating. Meanwhile, strategically positioned post-high-pressure turbine, the reheater takes on a pivotal role by reheating steam from the turbine's initial stages as it enhances the power plant's thermal efficiency. This process enables greater steam expansion in the turbine, extracting maximum energy before condensation, thus revolutionizing energy extraction in boiler systems.

2.0 OBJECTIVE

1. Revolutionize water level regulation in the drum and reheater by pioneering advanced State Space Models (SSM).
2. Elevate output parameter estimation accuracy through cutting-edge integration of Fuzzy State Space Models (FSSM) into the system.
3. Pioneer groundbreaking simulations of uncertain model parameters for the drum and reheater components, pushing the boundaries of predictive modeling in boiler system innovation.

3.0 METHODOLOGY

3.1 STATE AND OUTPUT EQUATION OF DRUM SYSTEMS

$$\begin{pmatrix} m_{dL} \\ x_{D1} \end{pmatrix} = \begin{pmatrix} -\frac{V_{dw}}{V_L} & 0 \\ 0 & -\frac{V_{dw}}{V_L} \end{pmatrix} \begin{pmatrix} m_{dL} \\ x_{D1} \end{pmatrix} + \begin{pmatrix} 1 & 1-x \\ h_e & (1-x)h_{wr} \end{pmatrix} \begin{pmatrix} W_e \\ W_r \end{pmatrix}$$

Figure 1 State Equation of Drum Systems

$$\begin{pmatrix} h_w \\ w_d \end{pmatrix} = \begin{pmatrix} 0 & \frac{1}{V_L \rho_w} \\ \frac{V_{dow}}{V_L} & 0 \end{pmatrix} \begin{pmatrix} m_{dL} \\ x_{D1} \end{pmatrix}$$

Figure 2 Output Equation of Drum Systems

3.2 STATE AND OUTPUT EQUATION OF REHEATER SYSTEMS

$$\begin{pmatrix} T_{rh} \\ X_{RH} \end{pmatrix} = \begin{pmatrix} -\frac{K_{rh} W_{ro}^{0.8}}{M_r C_{rh}} & 0 \\ \frac{K_{rh} W_{ro}^{0.8}}{V_{rh}} & -\frac{W_{ro}}{V_{rh} \rho_{rh}} \end{pmatrix} \begin{pmatrix} T_{rh} \\ X_{rh} \end{pmatrix} + \begin{pmatrix} \frac{1}{M_r C_{rh}} & 0 & \frac{K_{rh} T_r}{M_r C_{rh} W_{ri}^{0.2}} \\ 0 & \frac{W_{ri}}{V_{rh}} & -\frac{K_{rh} T_r}{V_{rh} W_{ri}^{0.2}} \end{pmatrix} \begin{pmatrix} Q_{rs} \\ h_{ri} \\ W_{ri} \end{pmatrix}$$

Figure 3 State Equation of Reheater Systems

$$\begin{pmatrix} P_{ro} \\ T_r \end{pmatrix} = \begin{pmatrix} 0 & R_r \left[\frac{h_{ro} - h_{ref} + C_{pr} T_{ref}}{h_{ro} C_{pr}} \right] \\ 1 & 0 \end{pmatrix} \begin{pmatrix} T_{rh} \\ X_{RH} \end{pmatrix}$$

Figure 4 Output Equation of Reheater Systems

3.3 FUZZY STATE SPACE MODELS TO EUCLIDEAN N-SPACE

Reheater Matrices Order

$A_{2\times2}, B_{2\times2}, C_{2\times2} \qquad k = 12$

$$S^*{}_4 = \left[a_{11}, a_{12}, a_{21}, a_{22}, 0,0,0,0,0, \frac{1}{M_s C_{rh}}, 0, \frac{w_{ri}}{V_{rh}}, 0,0,0 \right]$$

Drum Matrices Order

$A_{2\times2}, B_{2\times2}, C_{2\times2} \qquad k = 12$

$$S^*{}_5 = \left[\frac{V_{dow}}{V_L}, 0,0, \frac{V_{dow}}{V_L}, 0,0,0,0,0,1, (1-x), h_e, (1-x)h_{wr}, 0,0 \right]$$

4.0 RESULTS

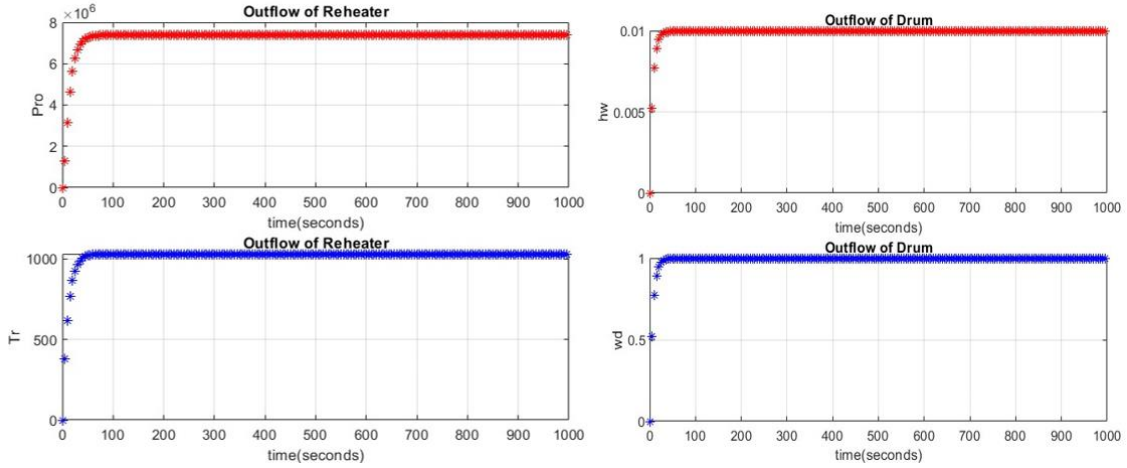

Figure 5 Outflow of Drum and Reheater Systems

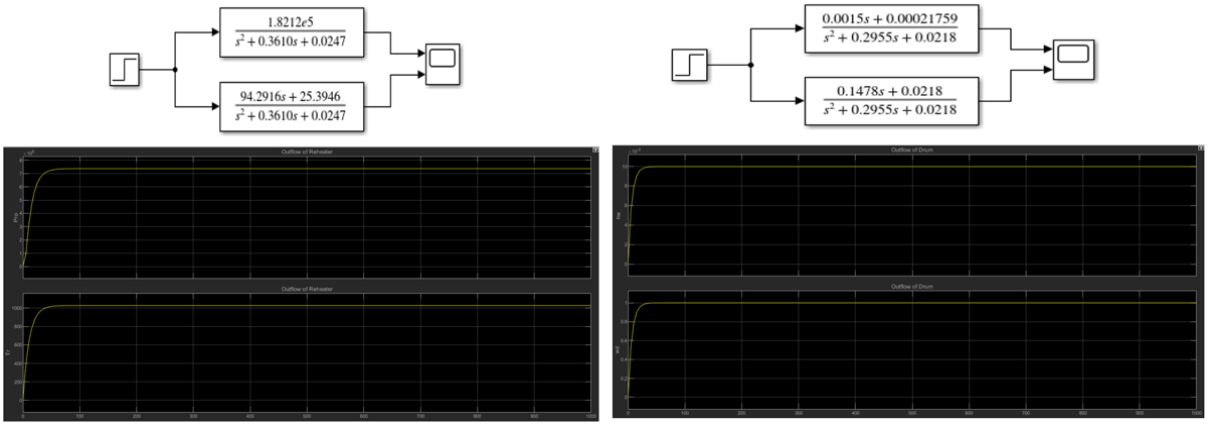

Figure 6 Outflow of Drum and Reheater Systems Via Simulink

5.0 CONCLUSION

This study has unveiled insights into the outflow levels from both the drum and reheater components of the boiler system. The compelling discovery of a congruent pattern between system operation and outflow underscores a remarkable synergy, suggesting an optimized operational paradigm. This finding not only validates the operational efficacy of the boiler's component system but also paves the way for innovative strategies in system optimization. By aligning operational performance with outflow dynamics, our study sets a new standard for efficiency in boiler technology, driving forward the frontier of sustainable energy solutions.