Leveraging Physics-Informed Neural Networks for Solutions of Differential-Algebraic Equation Systems

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INTRODUCTION

- Differential-Algebraic Equations (DAEs) govern complex systems like the Two-Phase Reactor and Condenser with Recycle (TPRCR).
- Traditional numerical methods face challenges: stiffness, sensitivity, and high computational cost.
- Physics-Informed Neural Networks (PINNs) integrate physical laws into neural network training for efficient and accurate solutions.
- Study goal: Validate PINNs for solving TPRCR's nonlinear DAEs, ensuring high accuracy and computational efficiency.

METHODOLOGY

- System Description: The **TPRCR** model involves chemical reactions, mass transfer, and phase equilibrium.
- PINN Framework: Loss function integrates residuals of differential and algebraic equations.
- Training Details:
- AdamW optimizer, 0.001 learning rate, 500 epochs.

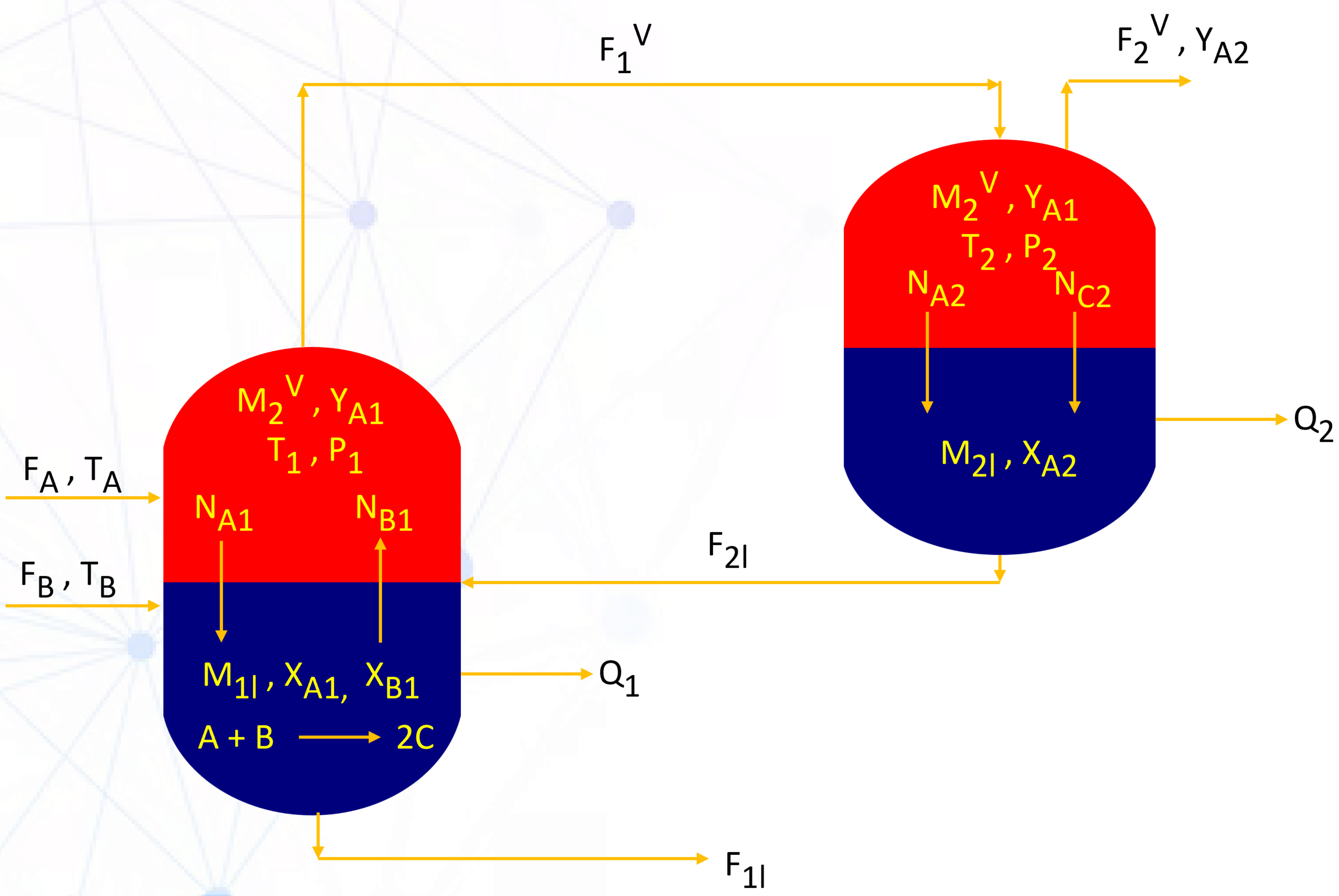

Figure 1: TPRCR System Schematic Diagram

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RESULTS

- PINNs accurately predicted system dynamics, closely matching DAE solutions.
- Effective handling of system stiffness and nonlinearities.
- Computational efficiency: Training completed in 2.03 minutes on an i7 13th generation processor.
- Low MSE values confirm high prediction accuracy for all variables.

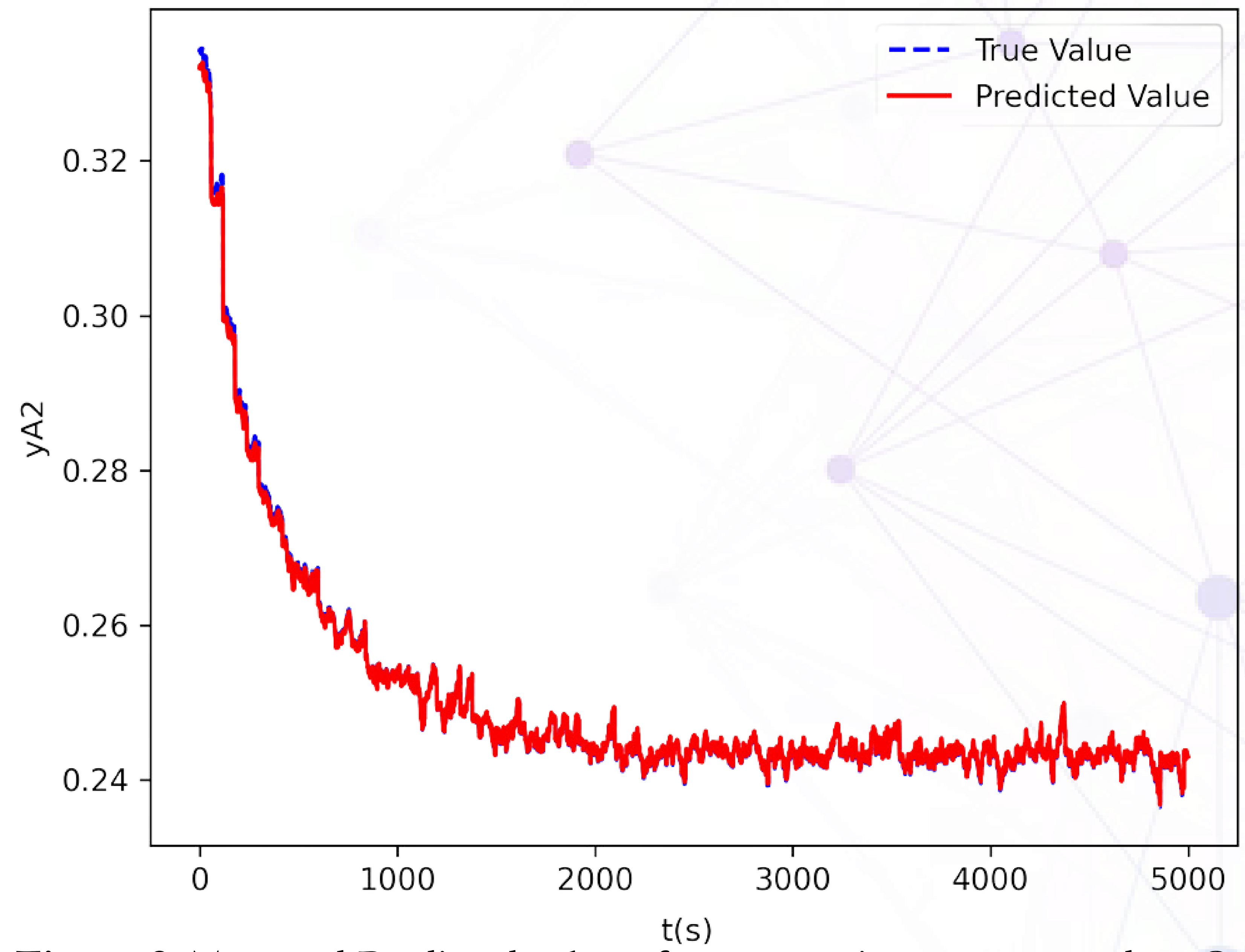

Figure 2: True and Predicted value of concentration vapour product C from the condenser outlet

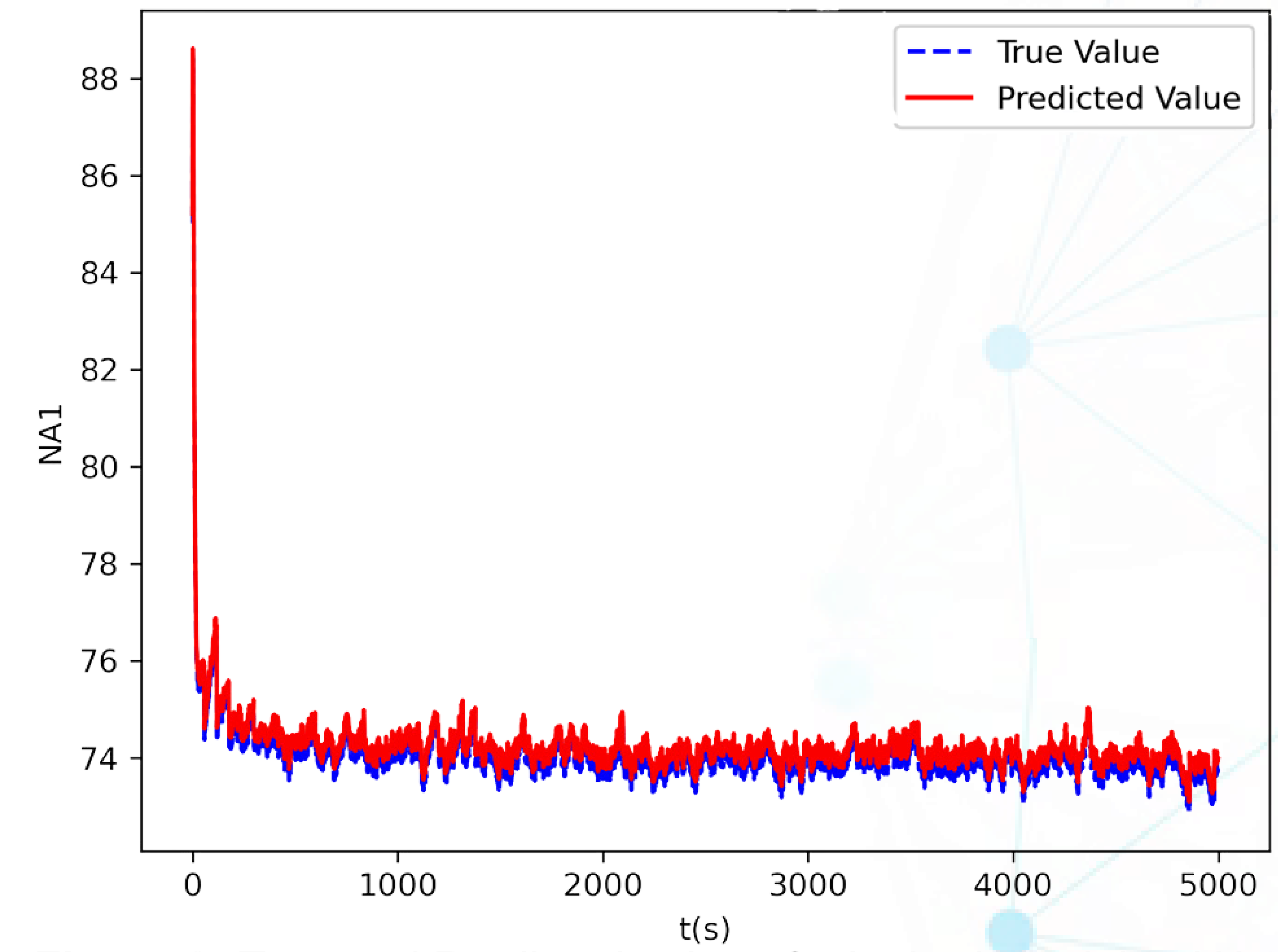

Figure 3: True and Predicted value of algebraic variable NA1

CONCLUSION

- PINNs demonstrated accurate and efficient solutions for the TPRCR system.
- Integrated physical laws enhance model reliability.
- Potential for wide applications in chemical engineering and beyond.