Development of a process system including high purity CO2 purity prediction/control technology for AI-based ships

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ABSTRACT

The maritime industry is facing increasing pressure to reduce greenhouse gas emissions in response to stringent international regulations led by the International Maritime Organization (IMO). Among various mitigation strategies, onboard carbon capture and storage (OCCS) has emerged as a promising solution. However, the practical implementation of OCCS on ships remains challenging due to severe constraints on space, weight, energy consumption, and safety, as well as highly dynamic operating conditions caused by fluctuating engine loads and marine environments.

A key feature of the proposed system is the application of artificial intelligence for intelligent process operation and optimization. Data-driven soft sensors are developed to estimate CO_2 purity and impurity concentrations in real time, compensating for limited or delayed onboard gas analyzers. Furthermore, AI-assisted predictive control is implemented to optimize operating conditions under varying load scenarios, minimizing energy consumption while maintaining product quality. Anomaly detection and fault diagnosis algorithms are also incorporated to identify early signs of process degradation, equipment malfunction, or abnormal operating conditions, thereby enhancing operational safety and reliability.

The results of this study indicate that the integration of AI with marine CO_2 purification processes can significantly improve operational efficiency, robustness, and safety. The proposed system provides a scalable and practical pathway for implementing high-purity onboard CO_2 processing, contributing to the advancement of maritime decarbonization technologies and future CCUS integration.

Keywords*: Marine carbon capture, High-purity CO_2, Artificial intelligence, Process optimization,OCCS*

Acknowledgements: This work was supported by Technology Innovation Program funded By Ministry of SMEs and Startups.

Presentation Type: Poster