International Conference on Numerical Combustion
Rome, Italy, October 14-17, 2025
www.icnc2025.com

Demonstration test of ammonia combustion in a mass-production scale glass melting furnace and validation of numerical simulation models

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Ammonia has emerged as a promising carbon-free fuel with the potential to significantly reduce greenhouse gas (GHG) emissions. As global efforts toward decarbonization accelerate, extensive research has been conducted to understand the combustion characteristics of ammonia and to develop reliable numerical modeling techniques. However, the application of ammonia combustion technologies to large-scale industrial processes remains limited.

To address these challenges, a joint project commissioned by the New Energy and Industrial Technology Development Organization (NEDO) was launched in Japan in 2021 (JPNP 21012), to explore the feasibility of direct ammonia combustion in industrial furnaces [1]. As part of this project, we conducted a full-scale demonstration test in a mass-production glass melting furnace. This test represents one of the first successful demonstrations of ammonia as a primary fuel in a large-scale, continuous production environment [2].

In this study, we report the results of the ammonia-oxygen combustion trial in the demonstration test, including thermal efficiency and NOx emissions under several operating conditions. Compared to the reference case of natural gas-oxygen combustion, ammonia-oxygen combustion showed slightly lower, yet still comparable, heat transfer efficiency to molten glass. Although an increase in NOx emissions was anticipated due to the nitrogen content in ammonia, the measured NOx levels were found to be approximately equivalent to those of the reference case. Potential mechanisms behind this phenomenon will be discussed.

Furthermore, we performed a numerical analysis using several chemical reaction mechanisms, with a particular focus on overall reaction models to validate their predictive capabilities against the large-scale trial data, since practical design studies for large industrial processes require computationally efficient approaches. In this study, we evaluated the applicability of such models, particularly in predicting heat transfer efficiency toward molten glass and NOx concentrations in the exhaust gas. The results provide insight into the trade-offs between computational efficiency and predictive accuracy, offering guidance for selecting effective modeling strategies in future ammonia combustion system designs.

[1] AGC Inc. (2022 Jan 13th). Ammonia Combustion Technology Development Project including AGC Selected as NEDO-Commissioned Project [Press release]. https://www.agc.com/en/news/detail/1202704_2814.html
[2] AGC Inc. (2023 Jun 27th). World's First Demonstration Test of Glass Production Using Ammonia as Fuel in Actual Production Furnace [Press release]. https://www.agc.com/en/news/detail/1203960_2814.html