Exploiting different heat supply strategies for on-board methanol reforming

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The hydrogen economy is increasingly impacting the maritime sector, driven by progressively stringent regulations on shipping emissions. Given the challenges of on-board hydrogen storage and logistics, hydrogen carriers such as methanol are often adopted as alternative energy vectors. In this context, methanol can be reformed on board to produce hydrogen, subsequently supplied to fuel cells for propulsion. Although compact commercial methanol reformers are available, their operational flexibility is often limited, restricting their adaptability across diverse marine applications. Furthermore, the common practice of supplying reforming heat by combusting part of the methanol reduces the system's decarbonization potential and generates pollutant emissions. Conversely, stand-alone reforming units offer greater spatial flexibility, facilitating more efficient integration within the constrained layouts of marine vessels.

Using commercial copper-based catalysts, methanol reforming typically operates at around 530 K—a temperature achievable through various heating strategies, including condensing steam, electrical heating, or flue gas recovery. The optimal heating approach depends on ship type and the availability of thermal energy sources. Moreover, the inherently transient nature of maritime operations—such as load changes and manoeuvring—may necessitate multiple reforming units to meet varying energy demands under different conditions.

This study critically evaluates the performance of methanol reforming systems under three heating strategies: electrical, condensing steam, and flue gas. The analysis is based on a fixed-bed multitubular reactor loaded with a commercial copper-based catalyst. A parametric sensitivity analysis is conducted to develop stability and performance maps, offering intuitive visualization of operating regimes and key performance trends. These insights support the design of more flexible and efficient hydrogen production systems for marine applications.

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