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Estimation of Energy Efficiency of Blue Hydrogen Production Onboard of Ships

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Abstract : The paper introduces an alternative concept of carbon capture for shipping by using pre-combustion carbon capture technology (Pre-CCS), which was proven to be less energy intensive than post-combustion carbon capture from the engine exhaust. Energy assessment on amine-based post-combustion CCS on LNG-fuelled ships showed that the energy efficiency of CCS ships reduced from 48% to 36.6%. Then, an energy assessment was carried out to compare the power and heat requirements of the most used hydrogen production methods and carbon capture technologies. Steam methane reformer (SMR) was found to be 20% more energy efficient and achieved a higher methane conversion than auto thermal reaction and methane decomposition. Next, pressure swing adsorber (PSA) has shown a lower energy requirement than membrane separation, cryogenic separation, and amine absorption in pre-combustion carbon capture. Hence, an integrated system combining SMR and PSA (SMR-PSA) with waste heat integration (WHR) was proposed. This optimized SMR-based integrated system has achieved 65% of CO_2 reduction with less than 7-percentage point of energy penalty (41.7% of energy efficiency). Further integration of post-combustion CCS with the SMR-PSA integrated system improved carbon capture rate to 86.3% with 9-percentage points of energy penalty (39% energy efficiency). The proposed system was shown to be able to meet the carbon reduction targets set by International Maritime Organization (IMO) with certain energy penalties.

Keywords : shipping, decarbonisation, alternative fuels, low carbon, hydrogen, carbon capture
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