Waste Heat Recovery in a Cruise Vessel in the Baltic Sea by Using an Organic Rankine Cycle: A Case Study - DTU Orbit (14/02/2019)

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Maritime transportation is a significant contributor to SOx, NOx, and particle matter (PM) emissions, and to a lesser extent, of CO2. Recently, new regulations are being enforced in special geographical areas to limit the amount of emissions from the ships. This fact, together with the high fuel prices, is driving the marine industry toward the improvement of the energy efficiency of ships. Although more sophisticated and complex engine designs can improve significantly of the energy systems on ships, waste heat recovery arises as the most effective technique for the reduction of the energy consumption. In this sense, it is estimated that around 50% of the total energy from the fuel consumed in a ship is wasted and rejected through liquid and gas streams. The primary heat sources for waste heat recovery are the engine exhaust and coolant. In this work, we present a study on the integration of an organic Rankine cycle (ORC) in an existing ship, for the recovery of the main and auxiliary engines (AE) exhaust heat. Experimental data from the engines on the cruise ship M/S Birka Stockholm were logged during a port-to-port cruise from Stockholm to Mariehamn, over a period of 4 weeks. The ship has four main engines (ME) Wärtsilä 5850 kW for propulsion, and four AE 2760 kW which are used for electrical generation. Six engine load conditions were identified depending on the ship’s speed. The speed range from 12 to 14 kn was considered as the design condition for the ORC, as it was present during more than 34% of the time. In this study, the average values of the engines exhaust temperatures and mass flow rates, for each load case, were used as inputs for a model of an ORC. The main parameters of the ORC, including working fluid and turbine configuration, were optimized based on the criteria of maximum net power output and compactness of the installation components. Results from the study showed that an ORC with internal regeneration using benzene as working fluid would yield the greatest average net power output over the operating time. For this situation, the power production of the ORC would represent about 22% of the total electricity consumption on board. These data confirmed the ORC as a feasible and promising technology for the reduction of fuel consumption and CO2 emissions of existing ships.

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