Modelling of an Advanced Waste Heat Recovery System for a Marine Diesel Engine

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The temperature of the exhaust gas of a marine diesel engine is generally between 250-500C^o. This heat is usually used to heat water for different heating purposes onboard the ship, however a vast amount of the energy in the exhaust gas is never used. Some modern ships uses a Rankine steam process to generate electricity to the ship from the waste heat in the exhaust gas, however the Rankine process is not ideal for such low temperatures.

The use of the Kalina Cycle for waste heat recovery is therefore investigated.
The thermodynamics and processes of the Kalina Cycle are described in detail, and a suitable configuration for waste heat recovery on marine diesel engines is presented. Configurations to improve the efficiency and thereby increase the electrical output are suggested and analysed as well.
By using the Kalina Cycle for waste heat recovery the overall efficiency of the energy system onboard the ship can be improved, thereby reducing emissions and reducing the fuel cost.

The Kalina systems are simulated in two cases; Case 1 where the exhaust gas has a lower temperature limit of 160C^o due to a high sulphur content in the fuel and Case 2 where the fuel is assumed without sulphur resulting in no lower limit of the exhaust gas temperature. This is done to show how changing from Heavy fuel Oil (HFO) to a fuel with lower sulphur content (such as natural gas) could result in higher efficiencies of the energy system and again reduce emissions further.

Simulations results were compared to results from a dual pressure Rankine waste hear recovery system. This showed that the Kalina system has a clear advantage over the Rakine system as it is more suited for lower temperatures.

The traditional engine system has an efficiency of 50.19% without a waste heat recovery system.
The Kalina cycle as waste heat recovery can increase the overall efficiency of the engine system, running on HFO, from 52.76% to 53.80% an improvement of 1.04 percentage points compared to a engine system using a Rankine waste heat recovery system. The highest efficiency was obtained for Case 2 where the Kalina system resulted in an efficiency of 55.22%; an improvement of 5.03 percentage points compared to the traditional engine system.

The improvements to the overall efficiency of the energy system will result in a significant emission and fuel cost reduction.