Solar Cavity Receiver for a Stirling Engine

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In this Bachelor thesis a solar cavity receiver together with a parabolic concentrating mirror has been designed for a Stirling engine, which traditionally runs on gas or bio-fuels. These design changes make it possible to run the engine on solar energy. This Dish-Stirling system has been designed with cost in mind, so it could be used in third world countries, thus cheap materials and production methods have generally been preferred over high performance and efficiency.

In this thesis, a thorough analysis of the concentrator, the receiver, and the cavity is made. The analyses was based on heat transfer, thermodynamics, and geometry calculations. These analyses resulted in a final design, which was compared to the existing gas-fired engine. An analysis of storage options was carried out, along with an economic analysis, in order to determine whether it is economically justifiable to invest in a Dish-Stirling system.

The final design of the receiver is seen in Figure 1. The tubes have been designed to capture all the incoming radiation from the sun.

Figure 1: The final receiver design

An economic analysis where the Dish-Stirling technology is compared to the photovoltaic technology was carried out. It was found that both technologies require subsidies to be economically justifiable, and that they are very similar with respect to pay-back period. In this relation examples of possible buyers was given and the perspectives of the Dish-Stirling technology were investigated. The analysis showed that the technology has great potential in small-scale decentralized energy production, for example in rural villages in third world countries.

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 250-500°C. 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 160°C 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 heat recovery system. This showed that the Kalina system has a clear advantage over the Rankine 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.