Simulated Optimization and Feasibility of a Thermoacoustics Engine in the Marine Environment

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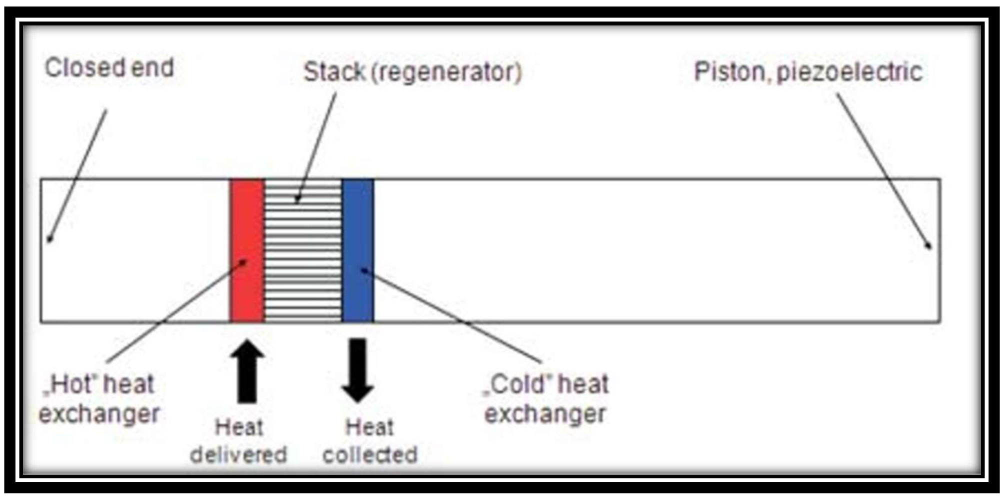
ABSTRACT

Thermoacoustics is the field of study that deals with the interaction of sound and heat to determine how energy is transferred between the two. The conversion of the waste heat to sound can subsequently be converted from sound to electrical energy by use of piezo electric crystals, or other similar devices, to power various electronical equipment. This is the basic principle behind a thermoacoustic engine, which was simulated in this paper using MATLAB programming. By varying three of the fundamental properties of the engine, a matrix of different power outputs was observed and compared. These were used in tandem with weight, cost, and size data in an optimization study that was aimed at analyzing the potential use of these systems for waste-heat recovery on ships. Two feasibility studies were performed on the most promising thermoacoustic engines. These results were compared to the same studies completed on a steam-turbine power-turbine. This led to the conclusion that, while economically feasible, thermoacoustic engines cannot currently compete with the efficiencies of conventional systems.

PROCEDURE

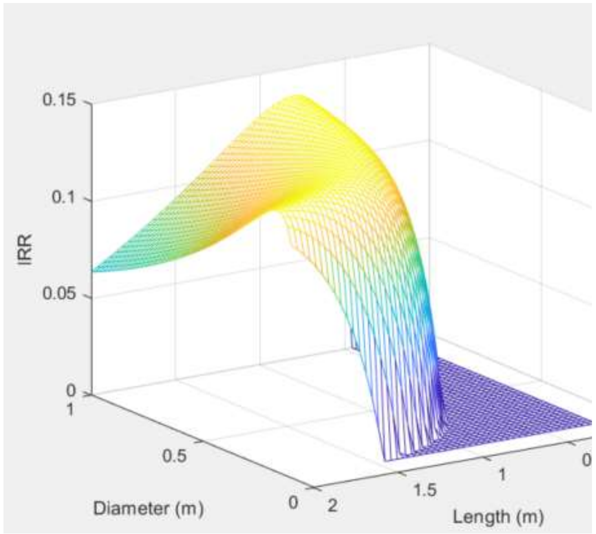
1. Research thermoacoustic engines (TAE)
2. Design input and output systems for the TAE
3. Program a TAE in MATLAB
4. Optimize engines based on length, diameter, and pressure
5. Conduct feasibility study on two voyages comparing to a steam-turbine power-turbine
6. Conclusion as to the feasibility of a TAE for use on ships

Thermoacoustic Standing Wave Engine



WHAT IS A TAE?

Thermoacoustic engines are a type of energy-transferring device which takes heat from an outside source and converts it to sound energy. These devices can come as either standing wave or traveling wave engines. The major components in a standing wave TAE can be found in the image above. These components are as follows: hot heat exchanger, setting the upper temperature limit, the stack, where the power is generated, the cold heat exchanger setting the lower limit, and the resonator tube, where the standing wave is maintained. Perhaps the most important feature of a TAE is the need for a critical temperature difference to occur across the stack. Without this, no energy will be produced.



FEASIBILITY STUDIES

Viking RoPax Ferry:

- Compared NPV and IRR for ST-PT and TAE
- Tallinn to Helsinki

West Coast Containership:

- Long haul voyage
- Used SD II containership design
- Operates between California and Hawaii

	Ferry Study			Containership	
Parameter	ST-PT	Optimized	Max NPV	ST-PT	Max NPV
Energy (kW)	3,654	353	958	3,120	366
Cost ($)	10,000,000	275,000	2,242,000	10,000,000	1,667,000
NPV ($)	9,552,400	1,218,500	3,175,900	9,917,100	504,710
IRR (%)	10.60	33.94	14.04	10.90	5.20

RESULTS

A table of results for our study is shown above. Shown is that a TAE is not yet a feasible alternative. Additionally, they appear to perform well when combined with a gas turbine, and not a low-speed diesel.

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