D1 The dying lake: Waikare and the embodied artist

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Thermoacoustic machines have received increased interest since Sondhauss' initial investigation into 'thermoacoustic oscillations' in 1850, due to their diminished environmental impact, and high reliability from the omission of moving parts. These machines rely on the Stirling cycle where gas performs energy conversion through the propagation of acoustic waves through a differentially heated regenerator. The direction of wave propagation determines the type of energy conversion: thermal to acoustic energy (engine) or vice versa (refrigeration). There are two types of waves 'standing' or 'travelling', but research has shown that the latter provides higher efficiencies due to the timing of the pressure and velocity peaks, which eliminate 'thermal delay' in the heating/cooling processes. These thermal delays are vital for a standing-wave device to convert any energy, but consequently reduce the effectiveness of the regenerator resulting in poor efficiencies.

The construction of a travelling-wave Thermoacoustic Stirling cooler by Ueda in 2004, following the production of an extremely efficient Thermoacoustic Stirling Engine (TASE) by Backhaus and Swift in 1999, illustrated the potential for achieving low temperatures with no moving parts and a relatively simple design. Unfortunately, the size limitations imposed by the resonator have hindered the exploration of small-scale versions for applications like aerospace.

In this paper, a numerical model of such a cooler will be developed in DeltaEC – a free software package created by Los Alamos National Laboratory for modelling thermoacoustic devices; through adaptation of the TASE proposed by Backhaus and Swift. The primary goals will be to reduce the overall size by minimising the area and length of the components – particularly the resonator and looped tube and attempt to increase the cooling capacity by varying operating parameters such as the mean pressure and frequency. The results will provide initial geometric estimates required to later construct an experimental prototype.

Keywords
Thermodynamics; Stirling; Acoustics; Cryocoolers; Travelling-wave; Numerical modelling; DeltaEC