

ABSTRACT

Numerical Modelling of Thermoacoustic Stirling Engines & Refrigerators

Holly Butson

Keywords: Thermoacoustics, standing wave, travelling wave, modelling, Sage, DeltaEC, Stirling, stack, regenerator

Thermoacoustic machines depend on the complex relationship between thermodynamics and acoustics, and thus understanding it is vital in order to analyse the working principles and optimise parameters (i.e. geometrical or operational) to improve their performance. This paper investigates how numerical modelling can be used to explore this relationship and compares the accuracy of the performance predictions for different numerical simulation software. The software used included one designed for modelling Stirling machines called 'Sage' and one designed for modelling thermoacoustic machines called 'DeltaEC'. To compare their results a model of both a thermoacoustic Stirling engine and refrigerator were developed from existing models in published papers, which contained experimental data to validate the numerical models. The results from the thermoacoustic Stirling engine model show that there is good agreement between the predictions from DeltaEC and the experimental data, as well as relatively good agreement between the Sage and DeltaEC predictions. However, due to Sage requiring a different approach to model the boundary conditions for the standing wave type machine (i.e. one end closed) the predictions varied slightly from those by DeltaEC. The results from the thermoacoustic Stirling refrigerator model, however, show improved agreement between the predictions from Sage and DeltaEC – potentially due to Sage and DeltaEC using a similar approach to model the boundary conditions for the travelling wave type (i.e. two open ends). Overall, it was found that although both can accurately model travelling wave thermoacoustic machines, the nature of Sage's solving method makes it more complex to model the standing wave type compared to DeltaEC. A discussion on the use of numerical models as a tool for better understanding thermoacoustic machines, and the importance of the accuracy of the results to allow for optimisation and improvement in their design is presented.

Mathematical Modelling Of Stirling Engines

Daniel F McAuley



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Numerical Modelling and Design Optimisation of Stirling Engines for Power Production Kwanchai Kraitong, 2012 This research is in the area of Thermal Energy Conversion more specifically in the conversion of solar thermal energy This form of renewable energy can be utilised for production of power by using thermo mechanical conversion systems Stirling engines The advantage of such the systems is in their capability to work on low and high temperature differences which is created by the concentrated solar radiation To design and build efficient high performance engines in a feasible period of time it is necessary to develop advanced mathematical models based on thermodynamic analysis which accurately describe heat and mass transfer processes taking place inside machines The aim of this work was to develop such models evaluate their accuracy by calibrating them against published and available experimental data and against more advanced three dimensional Computational Fluid Dynamics models The refined mathematical models then were coupled to Genetic Algorithm optimisation codes to find a rational set of engine s design parameters which would ensure the high performance of machines The validation of the developed Stirling engine models demonstrated that there was a good agreement between numerical results and published experimental data The new set of design parameters of the engine obtained from the optimisation procedure provides further enhancement of the engine performance The mathematical modelling and design approaches developed in this study with the use of optimization procedures can be successfully applied in practice for creation of more efficient and advanced Stirling engines for power production

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