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C3Or4C-08: Numerical investigation & optimisation of a small-scale travelling-wave thermoacoustic Stirling cryocooler

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Thermoacoustically driven cryocoolers have been an area of significant interest due to the driving mechanism being heat, which hence eliminates the need for moving mechanical parts and thus increases simplicity and reliability. A small-scale travelling-wave thermoacoustic Stirling cryocooler of this nature was designed and optimised in the thermoacoustic modelling software 'DeltaEC.'The cryocooler consisted of a resonator connected to a looped tube containing two thermoacoustic cores: one which acted as an engine to produce acoustic work (TASE), and one as the cooler that converted this acoustic work to thermal energy to produce cooling (TASC). The purpose of the project was to investigate whether a small-scale version could be feasible and how the geometry could be optimised to improve its performance. Parameter studies focusing on the mesh number and wire diameter for the regenerators as well as the plate spacing and length for the heat exchangers were conducted to explore how they affect the cooling capacity and coefficient of performance (COP) of the machine. The results showed that for the TASC increasing the wire diameter decreases the cooling capacity for all mesh numbers but increases the COP for mesh numbers below 200, whilst for the TASE both the cooling capacity and COP decreases. However for the heat exchangers in both the TASC and TASE it was found that increasing the length initially increases the cooling capacity and COP for all plate spacings but beyond 30 mm they begin to plateau and eventually decrease. Then various combinations were evaluated in DeltaEC to determine the optimal dimensions that would maximise the cooling capacity and COP. Using the optimised dimensions, the cooling capacity improved significantly from 106.38 W to 633.80 W, and the COP from 6.93 % to 23.70 %.

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