Development of a Diaphragm Stirling Cryocooler

A. Caughley1, M. Sellier2, A. Tucker, M. Gschwendtner3

1Callaghan Innovation, Christchurch, New Zealand

2University of Canterbury, Christchurch, New Zealand
3TS-dot Engineering, Auckland, New Zealand

Callaghan Innovation, formerly Industrial Research Ltd, has developed a novel free piston Stirling cryocooler concept using metal diaphragms. The concept uses a pair of metal diaphragms to seal and suspend the displacer of a free piston Stirling cryocooler. The diaphragms allow the displacer to move without rubbing or moving seals to produce a long-life mechanism. When coupled to a metal diaphragm pressure wave generator, the system produces a complete Stirling cryocooler with no rubbing parts in the working gas space.  Initial modeling of this concept using Sage indicates the potential for a useful cryocooler. A proof of concept prototype was constructed and achieved cryogenic temperatures. CFD modeling of the heat transfer in the radial flow fields created by the diaphragms shows the possibility of utilizing the flat geometry for heat transfer, reducing the need for, or the size of, expensive heat exchangers.

A second prototype has been designed and constructed using the experience gained from the first prototype. Further CFD modeling has been used to understand the underlying fluid-dynamic and heat transfer mechanisms and refine the Sage model. The prototype produces 29 W of cooling at 77 K and reaches a no-load temperature of 56 K. This presentation details of the development, modeling and testing of the second iteration prototype.