Numerical and Experimental Analysis of Internal Thermally Active Oscillating Gas Flows of a Pulse Tube Cryocooler

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Low temperature refrigeration is used in a variety of industries. One method of creating low temperature cooling is the pulse tube cryocooler. Currently these systems only operate at 5-15% of their Carnot efficiency. In order to further the field of optimizing these systems for improved performance, the goal of this project is to experimentally validate numerical models of pulse tube cryocoolers.

In order to validate the simulations, it is best practice to use a non-contact base measurement technique. Contact based techniques mechanically disturb the flow reducing the reliability and accuracy of the measurement. A suitable non-contact measurement technique for this validation is Molecular Tagging Velocimetry and Thermometry (MTV-T). This technique not only allows for the measurement of a flows velocity field, but also its temperature distribution.

The pulse tube numerical models were created using ANSYS and simulated using Fluent. The velocity vectors of the flow were extracted for various time intervals during the cycle to be compared to the experimental data from the MTV-T. An experimental apparatus was created to model the boundary conditions of the simulation as closely as possible. The apparatus features both warm and cold heat exchangers, and a glass pulse tube through which the flow can be visualized. Utilizing a pulse laser, a digital delay generator, and two high resolution cameras, this project was able to prove that MTV-T can be used for very low speed gaseous flows effectively.

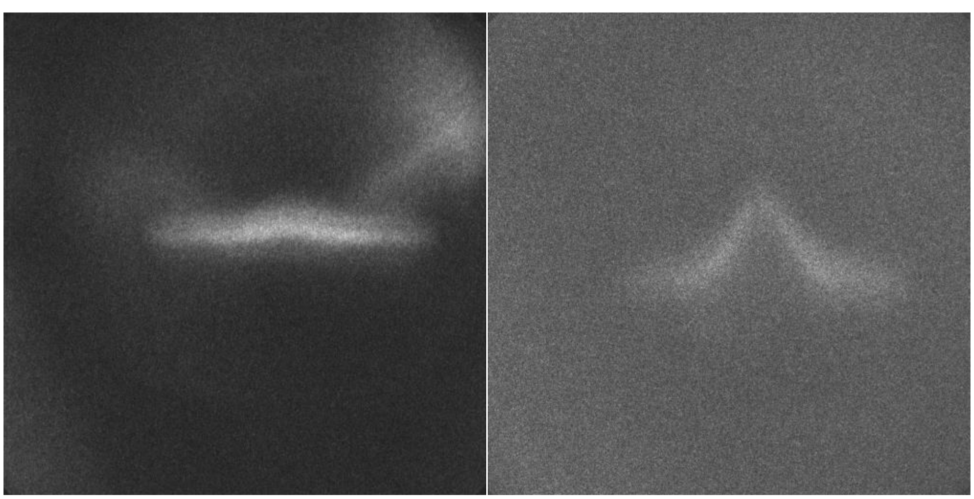

Figure 1: Photograph showing the low-speed flow of gas using MTV-T.