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Optimization of Phase Controller for Pulse Tube Cryocooler

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The development of pulse tube cryocoolers has increased rapidly because of its mechanical simplicity and high reliability due to the absence of moving parts in the cold region. Pulse tube cryocoolers are suitable for cooling of infrared sensors, low noise electronic applications, liquefaction of gases, etc. A Pulse Tube Cryocooler performance depends on the phase controller. The phase controller used here is inertance tube-bounce space. The phase difference between the compressor and bounce space flow is around 180º. If this phase difference is utilized, the inertance tube-bounce space combination can act as a compact phase shifter. The objective of this paper is to optimize the dimensions of the inertance tube and bounce space for the best performance of Pulse Tube Cryocooler. The performance of a Stirling pulse tube cryocooler is maximum when the pressure and mass flow are in phase at the midpoint of the regenerator. To achieve this phase shift in acceptor, the pressure should lag the mass. A Cryocooler system was designed using Sage software, which uses inertance tube-bounce space as a phase shifter. The maximum power input to the cryocooler was limited to 100W. Simulations were conducted for varying inertance tube dimensions (diameter and length), reservoir volume, frequency, and charge pressure. This model was used to maximize the cooling effect for the highest COP. The COP of the optimized cryocooler was found to be 0.043, which is 16% of the Ideal COP of pulse tube cryocoolers.