Contribution ID: **312** Type: **Poster Presentation**

Theoretical and experimental investigations on the performance characteristics of the linear compressor for the pulse tube cryocooler

Tuesday 30 June 2015 09:00 (2 hours)

The linear compressor providing powers for the Stirling-type pulse tube Cryocooler (SPTC) is endowed with remarkable merits such as high reliability and long life which have a strong appeal to aerospace applications. The pulse tube cold finger (PTCF) exerts evident and complicated influences on the compressor's performance. However, there is seldom systematic investigation on the influences, which often leads to a poor cooler performance when a linear compressor is developed and then coupled to the PTCF.

In this paper, theoretical and experimental investigations on the linear compressor's performance characteristics and the PTCF's influences have been made. The compressor and the PTCF are assumed as a one-dimensional thermodynamic model. The governing equations of the working gas'operating characteristics are summarized, such as the dynamic pressure, the mass flow rate, and the phase angle between them. The cooling performance's effects on the characteristics of the working gas in the compression space are determined. Based on the characteristics of the working gas in the compression space, the governing equations of the compressor's performance characteristics are deduced, such as the input electric power, the PV power, and conversion efficiencies of powers. The principles for achieving the compressor's optimal performance are discussed in detail.

The experimental investigations are conducted on a series of linear compressors which drive SPTCs operating at 25-200 K. Varying with cooling capacities and operating temperatures, the linear compressors'input electric powers, conversion efficiencies, and the working gas'operating characteristics in the compression space are measured to verify the model. The SPTCs achieve input compressor capacities of 0-500 W with motor efficiencies of 74.2-83.6%, and 2.9%, 9.6%, 16.2% of Carnot efficiency at 40 K, 60 K, 80 K, respectively.

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Session Classification: C2PoB - Stirling and Pulse Tube Cryocoolers

Track Classification: CEC-04 - Cryocoolers (Aerospace)