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C2Or2C-06: Generalization of pulse tube cooler characteristics from the aspects of thermodynamics, acoustics and fluid dynamics

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The past 20 years have seen great advances of pulse tube coolers. Behind these are the deeper and clearer understanding of their working principles and more accurate simulation aided by more powerful computing capability. This paper mainly generalizes the author's understandings of the system, especially from the aspects of thermodynamics, acoustics and fluid dynamics. Maybe the most intriguing part is thermodynamics. The essential difference with ordinary steady flow system is that there is no gas portion that goes through all the components in a pulse tube cooler and there is no single P-V or T-S diagram that can cover all the thermodynamic cycles inside the system. This feature actually brings fundamental changes in understanding how the system operate, which overturns previous classical understanding of the Stirling coolers. Meanwhile, the same oscillating nature of the flow inside the pulse tube cooler easily lends to the use of acoustic theory to interpret the dynamics inside the cooler and leads to a more efficient design methodology as well as more innovations. As the final part, our most recent work, which, a little bit ironically, shows that in the porous regenerator, one may not need to think about the change brought about due to this oscillating nature when considering the flow resistance coefficient.

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