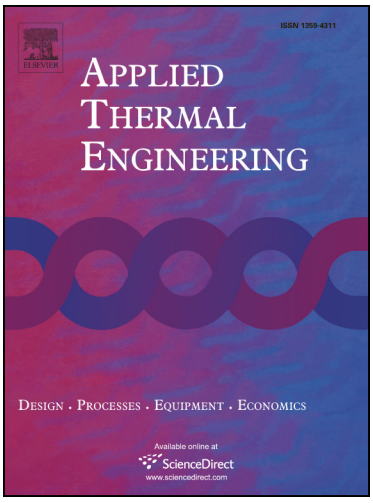

Research Paper

Effect of impedance on a compressor driving pulse tube refrigerator

A.K. Zhang, Y.N. Wu, S.S. Liu, H.F. Zhu, Y.P. Zeng, J.H. Jiang, A.K. Kan

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Effect of impedance on a compressor driving pulse tube refrigerator

A.K. Zhang*, Y.N. Wu*, S.S. Liu, H.F. Zhu,Y.P. Zeng, J.H. Jiang, A.K. Kan

Shanghai Institute of Technical Physics, Chinese Academy of Sciences, 500 Yu Tian Road, Shanghai 200083, PR China

Abstract

An impedance method is applied in a linear compressor driving a pulse tube refrigerator (PTR) to realize the maximum electric-to-acoustic efficiency. Some basic principles of the compressor are constructed, and its electric-to-acoustic efficiency is analyzed based on force balance and voltage balance equations, which is helpful for confirming how to tune the impedance to increase the performance of the PTR. A cold finger is designed and tested to couple well with the compressor, and the electric-to-acoustic efficiency can be improved by adjusting the pressure and inertance tube length, which have direct influences on the impedance's real and imaginary parts. In addition, some experiments are performed on a prototype refrigerator working with a frequency of 50 Hz and the experimental results are in good agreement with the theoretical analysis. Finally, the performance map is presented, and the highly efficient PTR can offer a cooling power of 6 W at 60 K cold temperature, which will be used to cool an aerospace HgCdTe infrared detector.

Keywords: Pulse tube refrigerator; Impedance; Cooling performance; HgCdTe infrared detector

1. Introduction

HgCdTe infrared detectors have been widely used in warning, reconnaissance, guidance, remote sensing satellites and astronomical detection. The optics of these detectors generally work in low-temperature environments of 60 K or less, which has greatly promoted the development of cryogenics, particularly the Stirling-type pulse-tube refrigerator (PTR) that lacks moving parts in the cold head, resulting in low vibrations and a long lifetime [1-4]. The PTR system is very complicated and its cold finger can be chosen as an appropriate load, whose available acoustic power is transferred from its compressor. Impedance matching is the practice of designing the

* *Corresponding author. Tel: +86-21-2505 1181.*
E-mail addresses: akzhang@mail.sitp.ac.cn (Ankuo Zhang), wyn@mail.sitp.ac.cn (Yinong Wu)