The Effect of Impedance on VM Type Thermal Compressor Output Characteristics for Obtaining Liquid Helium Temperature

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The Vuilleumier cryocooler is driven by a classical thermal compressor, which utilizes temperature difference between the ambient and the lower temperature to generate an oscillating pressure wave. This type thermal compressor is called as VM type thermal compressor spontaneously, normally working at low frequency, and can be used to drive low temperature stage pulse tube cold head. VM type pulse tube cryocooler has the potential advantages of compactness and high efficiency, which is attracting more and more attentions to achieve liquid helium temperature, and can be applied in HTS, MRI, et al. Based upon thermoacoustic theory, the impedance matching between thermal compressor and low temperature stage pulse tube cryocooler is of great significance to achieve higher efficiency. The output characteristics of VM type thermal compressor for driving pulse tube cryocooler with numerical simulation was studied in this paper. For the thermal compressor, dependency of the pressure ratio and acoustic power on the load impedance changing with certain scopes have been presented and discussed. The amplitude of impedance ranges from 5E8 to 5E9 Pa·s/m3 , and phase angle of impedance varies from -70° to 70°. The output pressure ratio is found to mainly depend on the phase angle of impedance while acoustic power is dependent on amplitude of impedance chiefly. To achieve the highest efficiency for the whole system, the option for the load impedance is a trade-off between above two factors. The study lays the foundation for designing a VM type pulse tube cryocooler working at liquid helium temperature as well as improving system performance.