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Cooling load and coefficient of performance of thermoacoustic refrigerators: the role of the working fluid

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Thermoacoustic refrigeration is a technology that uses mechanical energy in the form of sound waves to drive a heat pumping process that offers an environmentally safe, relatively low maintenance alternative to vapor compression refrigeration. Improving the design of the thermoacoustic core, composed of the stack plates and heat exchangers, may have the potential to bring thermoacoustic technology closer to commercial use. The stack plates have been analyzed to increase efficiency (expressed in terms of the coefficient of performance, COP) but in some applications a very high efficiency can lead to a smaller cooling load. The thermoacoustic stack was analytically optimized for maximum heat transfer (cooling load) and coefficient of performance (COP) for a range of working fluids of interest. Different noble gas mixtures were analyzed as the working fluid and helium was found to produce the highest cooling load because of its low molecular weight. The thermoacoustic stack plate center location, length, thickness and spacing were analyzed and optimum values to maximize cooling load and COP were found to exist for the specific input parameters considered. These optimization techniques may be used to design devices where maximum cooling load is more desirable than high efficiency.