Numerical Investigations on Flow Resistance Values for Pulse Tube Cryocoolers

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Pulse tube cryocoolers are usually modelled as one-dimensional flow fields. It has been proven that this assumption holds only for components having large L/D ratios [1]. However, during these CFD analyses of cryocoolers, there has always been some discrepancy between the modelled and the actual operating conditions. Commonly, a pulse tube cryocooler model consists of a compressor, an aftercooler, a regenerator, a pulse tube, hot and cold end heat exchangers, a phase shift device along with a reservoir. Modelling of the regenerator, hot and cold heat exchangers using realistic input values of viscous and inertial resistances prove to be crucial towards the assumption of one-dimensional flow fields.The present work deals with the numerical investigations on the effect of these viscous and inertial resistance values for all porous media. Analyses of individual porous components, viz. regenerator along with cold end heat exchanger and aftercooler along with hot end heat exchanger are executed. The base case taken under investigation is by Cha et al. [1]. The results of resistance values for unidirectional flow and at room temperature by using Ergun's equation are validated. The case is further modified for the operating pressure suitable to employ the resistance values for oscillating flow and at cryogenic temperatures. It is concluded that there is a substantial difference in the predictions of the cryocooler performance, mainly in terms of the no load temperature. This makes the model much more realistic.[1]. Cha, J. S., Ghiaasiaan S. M., Desai, P. V., Harvey, J. P. and Kirkconnell C. S., "Multi-Dimensional Flow Effects in Pulse Tube Refrigerators," Cryogenics 46, (2006), pp. 658–665.