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Comparative Study and Electromagnetic Analysis of Linear Drive System for a Stirling Cryocooler

Stirling cryocoolers are becoming more popular in the area of remote sensing and space applications because of their inherent characteristics viz., long life, high reliability, less weight etc. In order to have a good on-board performance, the selection of the compressor drive system is critical. Linear motors are simple in operation by avoiding side forces and the required axial force is generated by current flowing in a magnetic field. The recent trend is to replace the moving coil with moving magnet type motors. This paper explores the possibility of employing a range of components and materials for the development of a linear drive system. The analysis includes material selection, electromagnetic design using electro-mechanical energy conversion method and comparison of different configurations in order to meet the stringent operating requirements of the cooler. The compact size, available permanent magnet sizes and overall volume and weight reduction are quite a few constraints for the design. A number of material combinations are tried during the study before finalizing the geometry of the motor. The finite element analysis (FEA) and simulation are carried out using Maxwell software. Parametric study is carried out for different magnet and coil combinations, geometrical structures, and material combinations. The effect of magnet displacement on thrust force developed is analyzed in detail for different combinations under consideration. The air gap flux density was to be maintained at a minimum level to obtain the required force to operate the piston. The dimensions of the core are finalized after determining the saturation flux produced while the motor in operation. The effect of varying the inner and outer core thickness and their geometry on the air-gap flux density and saturation limits are also studied and compared with. The results are presented in the graphical and tabular forms.

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