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Effect of operating frequency and phase angle on performance of Alpha Stirling cryocooler driven by a novel compact mechanism

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Literature suggests that Alpha configuration Stirling cryocooler shows better theoretical performance when compared with Gamma configuration cryocooler. However, this has not been confirmed experimentally due to non-availability of drive mechanism providing large stroke to diameter ratio for Alpha cryocooler. The concept of novel compact drive mechanism can be used to operate miniature Alpha Stirling cryocoolers. The drive mechanism allows the use of multi-cylinder system while converting rotary motion to reciprocating motion. A stroke to diameter ratio of three is chosen and the drive dimensions are calculated for four piston-cylinder arrangements with 90o phase difference between adjacent arrangements providing two Alpha Stirling cryocoolers working simultaneously. It is also possible to use the drive mechanism to drive two different configurations of Stirling cryocooler simultaneously viz., Alpha configuration and Gamma configuration with equal volume displacement for the compression space. Due to specific arrangement in this drive mechanism, the combined peak torque requirement falls by 26.81% below the peak torque needed when only one unit is considered separately, leading to use of a comparatively lower torque motor.
For the thermodynamic analysis, second order cyclic analysis provides a simple computational procedure. Losses leading to decrease in refrigerating effect and increase in power requirement are calculated using appropriate equations from available co-relations for the conditions prevailing in the present system. The effects of phase angle between compressor and expander pistons as one parameter and the operating frequency as the other parameter, keeping other parameters fixed are presented in this paper. The maximum net refrigeration effect as well as COP is available at phase angle of 81o. However, in order to have a symmetrical system, the phase angle is fixed at 90o for both, the Alpha as well as Gamma cryocoolers. The cryocooler performance enhances with increase in operating frequency.

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