The pulse-tube cryocooler is a refrigerator which operates with a closed gas cycle has the advantage over Stirling cryocooler and has no moving mechanical parts in the cold head. Here the mechanical work produced by a compressor is transformed into refrigerating power.

For applications such as cooling the IR detectors and of non-dissipating superconducting circuits, the cryocooler needs to be further miniaturized.

An Engineering Model PTC with targeted specification of 1W at 80 K with an input power of around 45 W and total mass of 4 kg is achieved.

To further reduce the mass of PTC, this work has been taken up.

Conservation of mass, momentum and energy equation for flow through tubes
\[
\frac{\partial \rho}{\partial t} + \frac{\partial \rho v}{\partial x} = 0
\]
\[
\frac{\partial (\rho v)}{\partial t} + \frac{\partial (\rho v^2 + p)}{\partial x} - f(\rho, T, v) = 0
\]
\[
\frac{\partial (\rho E)}{\partial t} + \frac{\partial (\rho E + p)}{\partial x} - \frac{\partial \sum j(\tau T/\alpha)}{\partial x} - \frac{\partial (\rho T, v)}{\partial t} = 0
\]

Conservation of energy equation for flow through porous media
\[
\frac{\partial \rho E}{\partial t} + \frac{\partial (\rho E + p)}{\partial x} - \frac{\partial (\rho E \phi w)}{\partial x} = 0
\]

Regenerator Analysis
- For a fixed choice of the parameters listed in Table, a maximum COP can be identified as a function of mass flux through the regenerator and length of the regenerator.
- REGEN 3.3 analysis yields a maximum COP for a regenerator length, L of 0.035 m and an inverse mass flux (A0/\rho0) of 0.0577 m³/kg respectively.
- The maximum COP at this optimum regenerator length and inverse mass flux at converged results of REGEN after 10,000 iterations is 0.1044 and the maximum Net Refrigeration Power is 2.156 W as shown in figures 3 and 4 below.

Figure 3: COP Vs A0/\rho0

CONCLUSION
A parametric design study on high frequency pulse tube cryocooler is carried out for an operating frequency of 100 Hz, charge pressure of 15 bar and a pressure ratio of 1:3.

The cold and hot end temperatures considered to achieve a cooling load of 1.0 W are 80 K and 300 K. The estimated performance of the high frequency pulse tube cryocooler is 1.02 W of cooling load at 80 K temperature with 25.8 W of PV power. The total mass of the cooler would be around 2.0 kg.

FUTURE PLAN
Based on the studies carried out, there are advantages on the total mass and size of the high frequency pulse tube cryocooler as compared to the present unit.

Since modeling of PTC in SAGE is at system level with the dead volumes associated with all the components of PTC, the performance of 1.02 W of heat lift at 80 K temperature is achieved. REGEN analysis is carried out at component level assuming ideal parameters resulting in a heat lift of 2.15 W at 80 K temperature.

This has to be validated experimentally. For this, it is planned to fabricate and demonstrate the high frequency pulse tube cryocooler. Achieving the required linear motor efficiency for the high frequency compressor needs to be studied further.

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