Experimental comparison of Pressure ratio in Alpha and Gamma Stirling cryocoolers with identical compression space volumes and driven simultaneously by a solitary novel compact mechanism

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Cryocoolers and Drive Mechanism

Cryocooler Camera 200.avi

- Kinematic friction drive
- Line contact between power transmitting surfaces
- Larger stroke
- Mechanical phase difference
- Speed reduction
- More than one cryocoolers in single ensemble
- Any arrangement of Stirling cryocooler
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Novel compact drive mechanism

Actual novel compact drive mechanism with compressors of two simultaneously driven Alpha Stirling cryocoolers

Compressor cylinders inter-connected below compressor pistons

K. D. Sant and S. L. Bapat
### Experimental results

#### Before interconnecting compressor cylinders

<table>
<thead>
<tr>
<th>Charge pressure (bar)</th>
<th>Cryocooler frequency (Hz)</th>
<th>Input power (W)</th>
<th>Cold-tip temperature (K)</th>
<th>Pressure Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Cooler 1</td>
<td>Cooler 2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>---------</td>
<td>---------</td>
</tr>
<tr>
<td>14.0</td>
<td>23.94</td>
<td>151</td>
<td>304.5</td>
<td>303.8</td>
</tr>
</tbody>
</table>

#### After interconnecting compressor cylinders

<table>
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</tr>
<tr>
<td>14.0</td>
<td>23.92</td>
<td>148</td>
<td>292.0</td>
<td>290.6</td>
</tr>
</tbody>
</table>

Experimental results with **Two Alpha Stirling cryocoolers** operating simultaneously
Experimental comparison of Pressure ratio in Alpha and Gamma Stirling cryocoolers with identical compression space volumes and driven simultaneously by a solitary novel compact mechanism

Gamma Stirling cryocooler

- Substantial annular leak across expander piston due to high pressure ratio
- Introducing new expansion space not connected to bounce space
- New expansion space connected to one of the compressors providing Gamma Stirling cryocooler
- Selected displacer unit not directly connected to bounce space
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Modified Experimental set-up

- Function generator
- Oscilloscope
- Pressure indicator
- Motorised displacer
- Compressor
- Motor housing
- Variable frequency drive
- Gas charging line
- Power supply to displacer
- Temperature indicator
- Cold tip in vacuum bell jar
- Wattmeter
Experimental comparison of Pressure ratio in Alpha and Gamma Stirling cryocoolers with identical compression space volumes and driven simultaneously by a solitary novel compact mechanism

Experimental results

<table>
<thead>
<tr>
<th>Charge pressure (bar)</th>
<th>Compressor frequency (Hz)</th>
<th>Motor power (W)</th>
<th>Displacer power (W)</th>
<th>Cold-tip temperature (K)</th>
<th>Pressure ratio</th>
</tr>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Alpha</td>
<td>Gamma</td>
</tr>
<tr>
<td>14.0</td>
<td>23.89</td>
<td>230</td>
<td>0.5</td>
<td>290.7</td>
<td>281.6</td>
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</tbody>
</table>

Motor frequency 48 Hz and electrical phase shift in Gamma unit 40°

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<tr>
<th>Charge pressure (bar)</th>
<th>Compressor frequency (Hz)</th>
<th>Motor power (W)</th>
<th>Displacer power (W)</th>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Alpha</td>
<td>Gamma</td>
</tr>
<tr>
<td>20.0</td>
<td>23.95</td>
<td>260</td>
<td>0.85</td>
<td>287.1</td>
<td>271.5</td>
</tr>
</tbody>
</table>

Motor frequency 48 Hz and electrical phase shift in Gamma unit 88°

Experimental results with **Alpha and Gamma Stirling coolers** operating simultaneously
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**Experimental results**

Pressure variations of Alpha and Gamma units on modified set-up at 23.95 Hz, 20 bar charge pressure without vacuum and MLI

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Conclusion

- Capacity of Alpha configuration is higher than that of Gamma under same operating conditions in absence of annular leak

- Analytical prediction made by Bapat [3] is experimentally verified
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THANK YOU