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

Sant K. D. [1, 2] and Bapat S. L. [1]

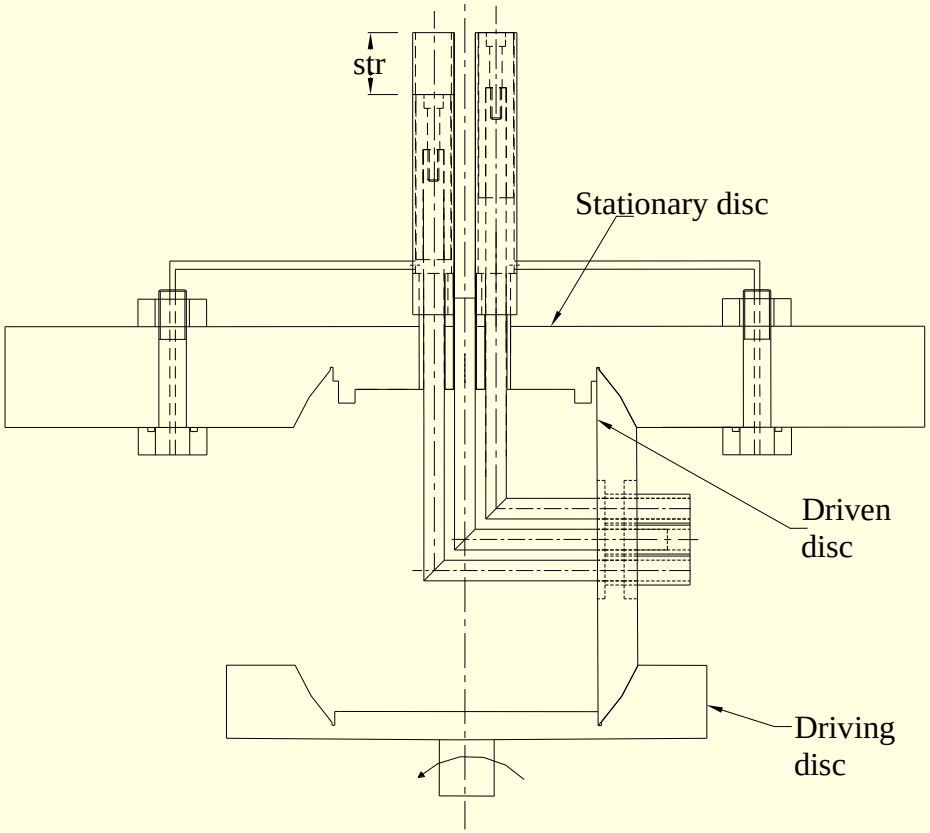
1 Department of Mechanical Engineering, IIT Bombay, Mumbai, India
2 Department of Mechanical Engineering, Vishwakarma Institute of Technology, Pune, India

Cryocoolers and Drive Mechanism

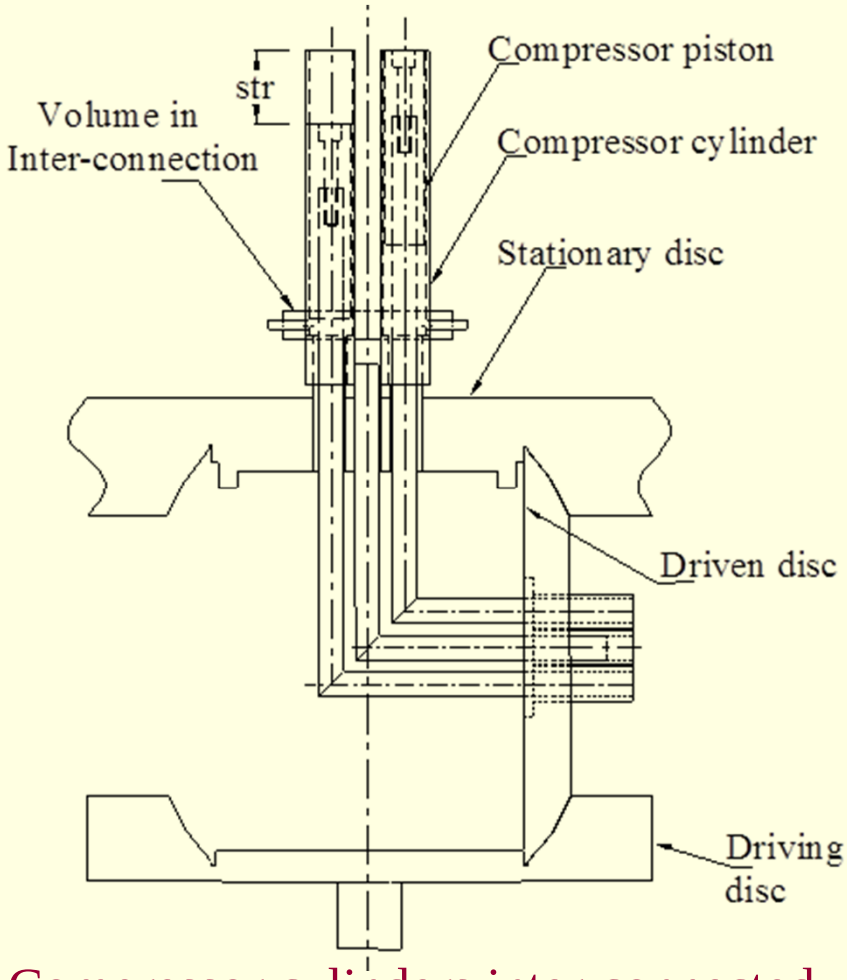
Cryocooler Camera 200.avi

- **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**

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

Experimental results

Before interconnecting compressor cylinders

Charge pressure (bar)	Cryocooler frequency (Hz)	Input power (W)	Cold-tip temperature (K)		Pressure Ratio
			Cooler 1	Cooler 2	
14.0	23.94	151	304.5	303.8	1.3538

After interconnecting compressor cylinders

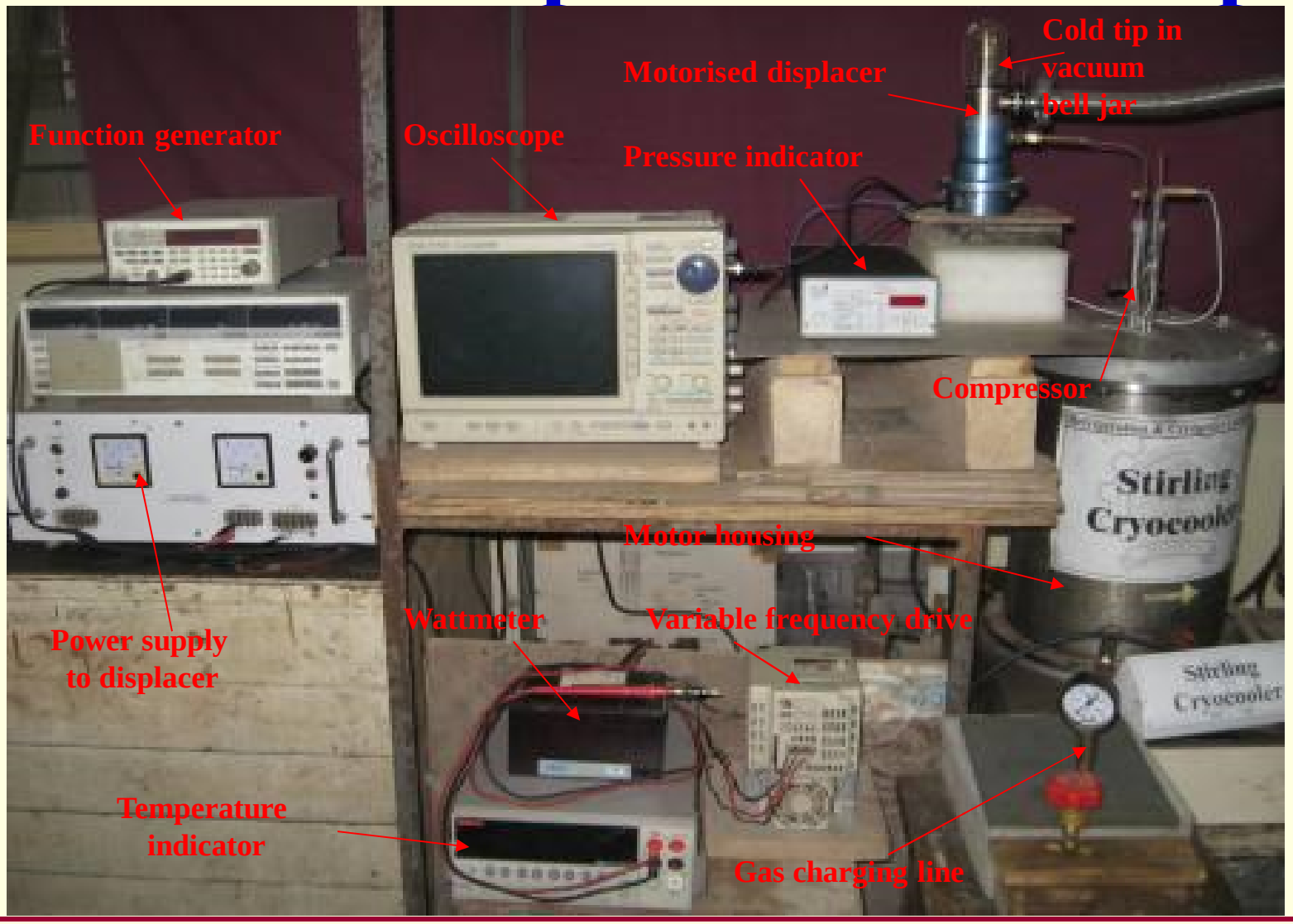
Charge pressure (bar)	Cryocooler frequency (Hz)	Input power (W)	Cold-tip temperature (K)		Pressure Ratio
			Cooler 1	Cooler 2	
14.0	23.92	148	292.0	290.6	1.417

Experimental results with **Two Alpha Stirling cryocoolers** operating simultaneously

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

Modified Experimental set-up



Experimental results

Charge pressure 14 bar

Charge pressure (bar)	Compressor frequency (Hz)	Motor power (W)	Displacer power (W)	Cold-tip temperature (K)		Pressure ratio	
				Alpha	Gamma	Alpha	Gamma
14.0	23.89	230	0.5	290.7	281.6	1.417	1.339

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

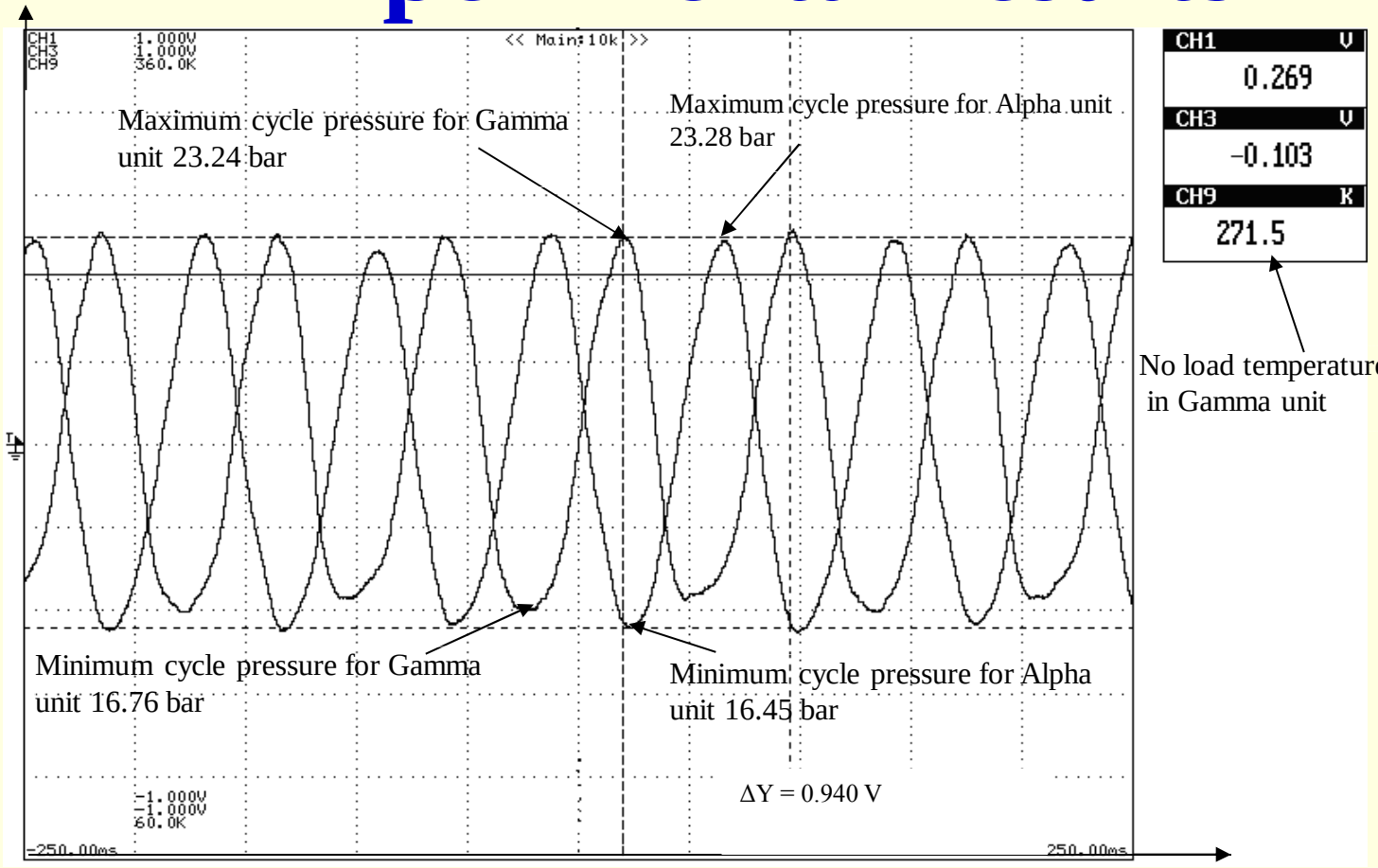
Charge pressure 20 bar

Charge pressure (bar)	Compressor frequency (Hz)	Motor power (W)	Displacer power (W)	Cold-tip temperature (K)		Pressure ratio	
				Alpha	Gamma	Alpha	Gamma
20.0	23.95	260	0.85	287.1	271.5	1.415	1.387

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

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

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

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**

THANK YOU