

Experimental Investigation on Stirling type Thermally Coupled Three Stage Pulse tube Cryocoolers with 'U' type Configuration

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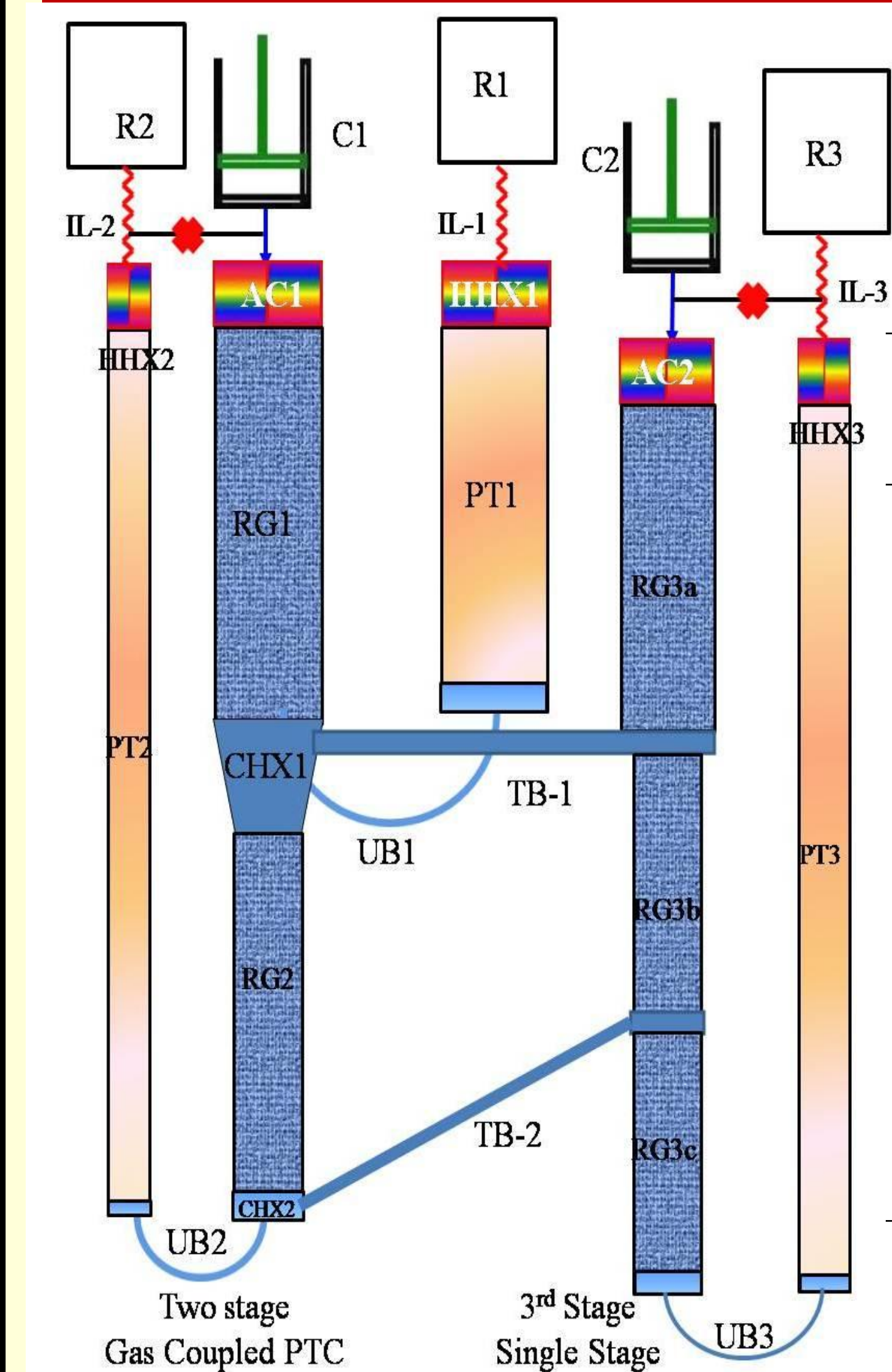
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OBJECTIVE

- To understand the concept of multi-staging of PTC
- Develop a Multi-stage Pulse Tube Cryocooler in order to achieve temperature below 20 K without using rare earth material.

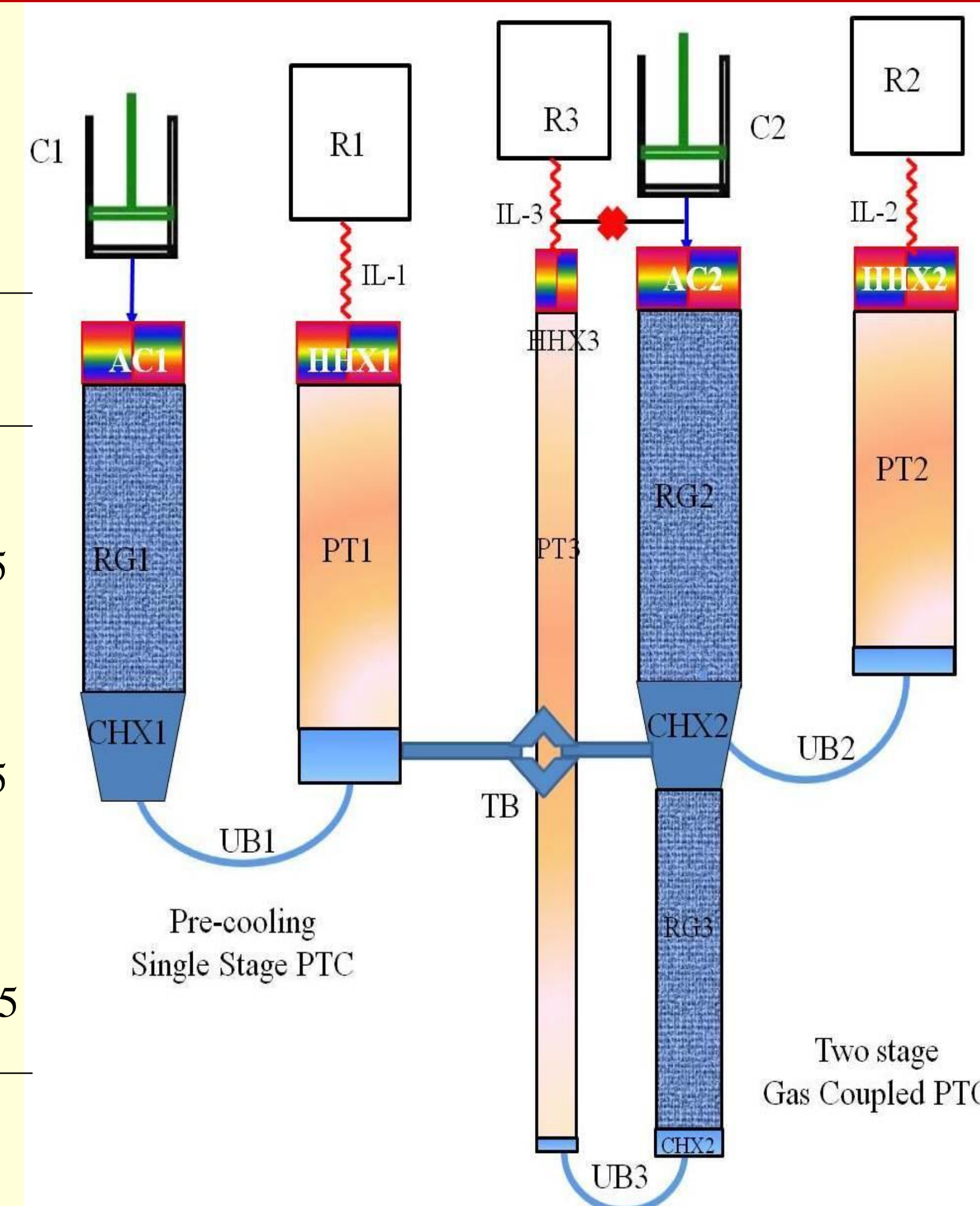
SCHEMATICS OF PTC



DIMENSIONS OF PTC

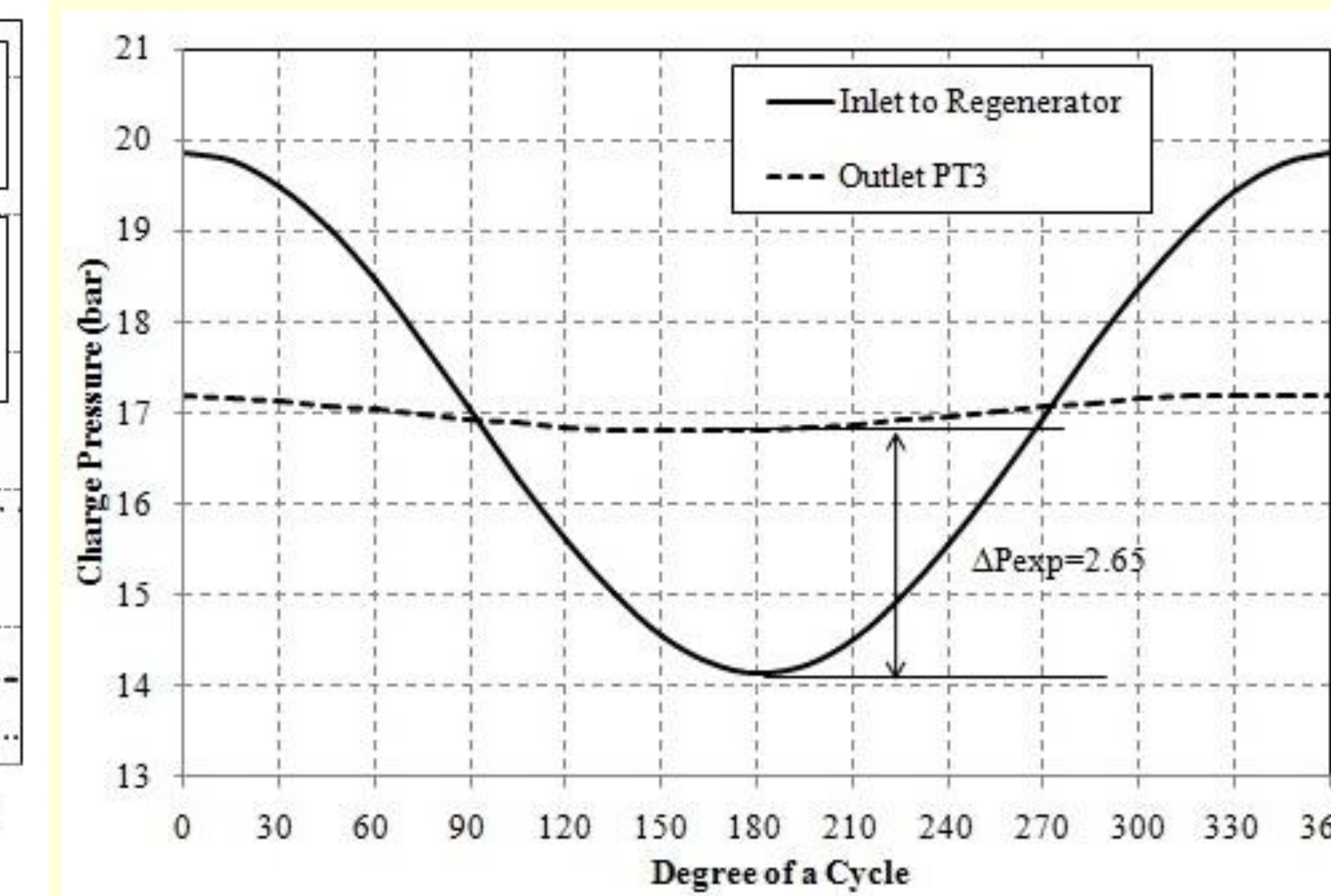
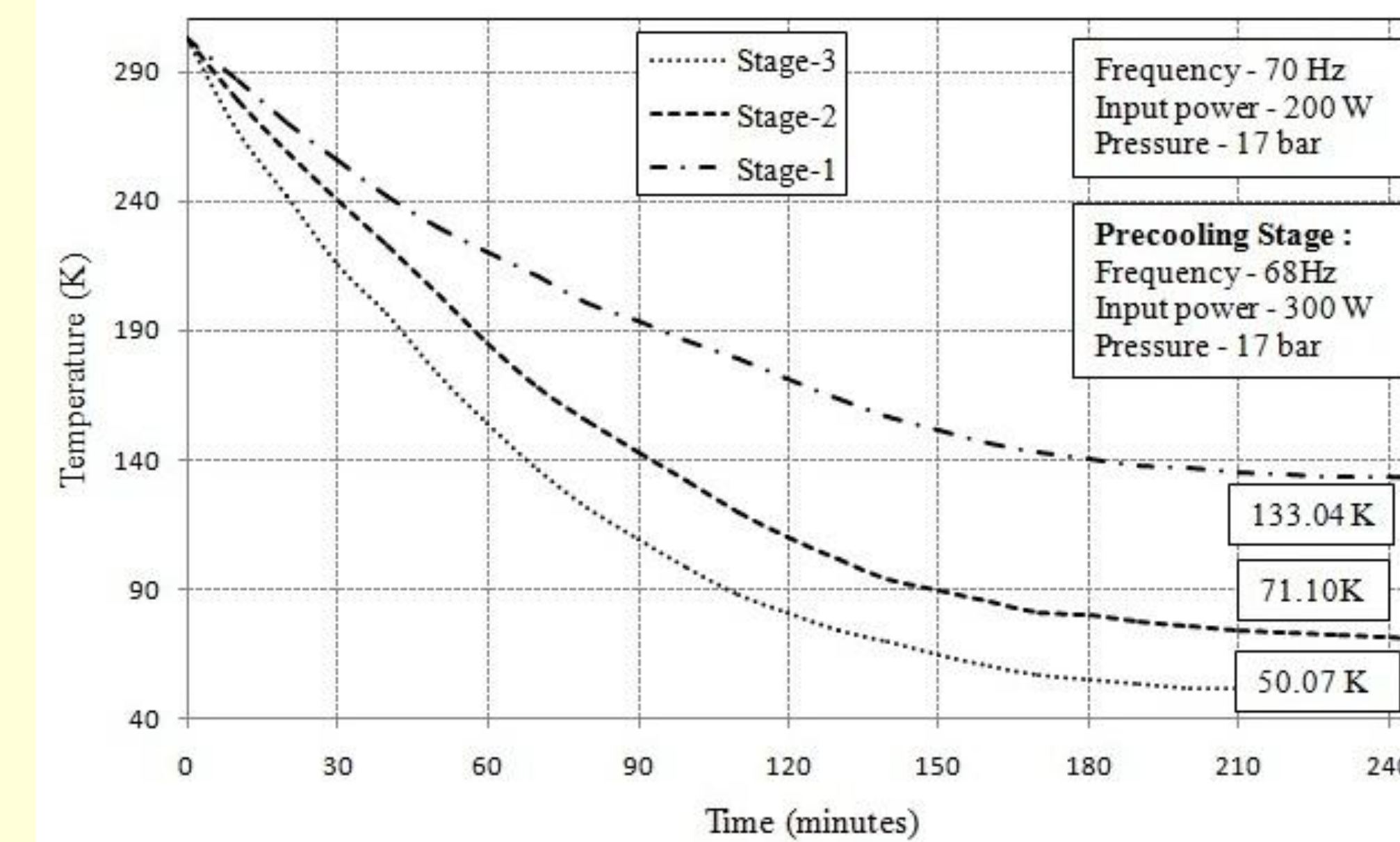
PTC Unit	Stages	Regenerator	Pulse Tube
Two Stage Gas Coupled PTC	1 st Stage	16 x 55 x 0.15	8 x 60 x 0.15
	2 nd Stage	9 x 60 x 0.15	4 x 140 x 0.15
Single Stage PTC for Case-1	Reg 3a*	12 x 55 x 0.15	
	Reg 3b*	8 x 65 x 0.15	4 x 180 x 0.15
	Reg 3c*	6 x 43.5 x 0.15	
Single Stage PTC for Case-2	-	28 x 54 x 0.15	12.2 x 74 x 0.15

* Sections of single regenerator as shown in figure for case 1



Case-2: Single stage as Precooling Stage

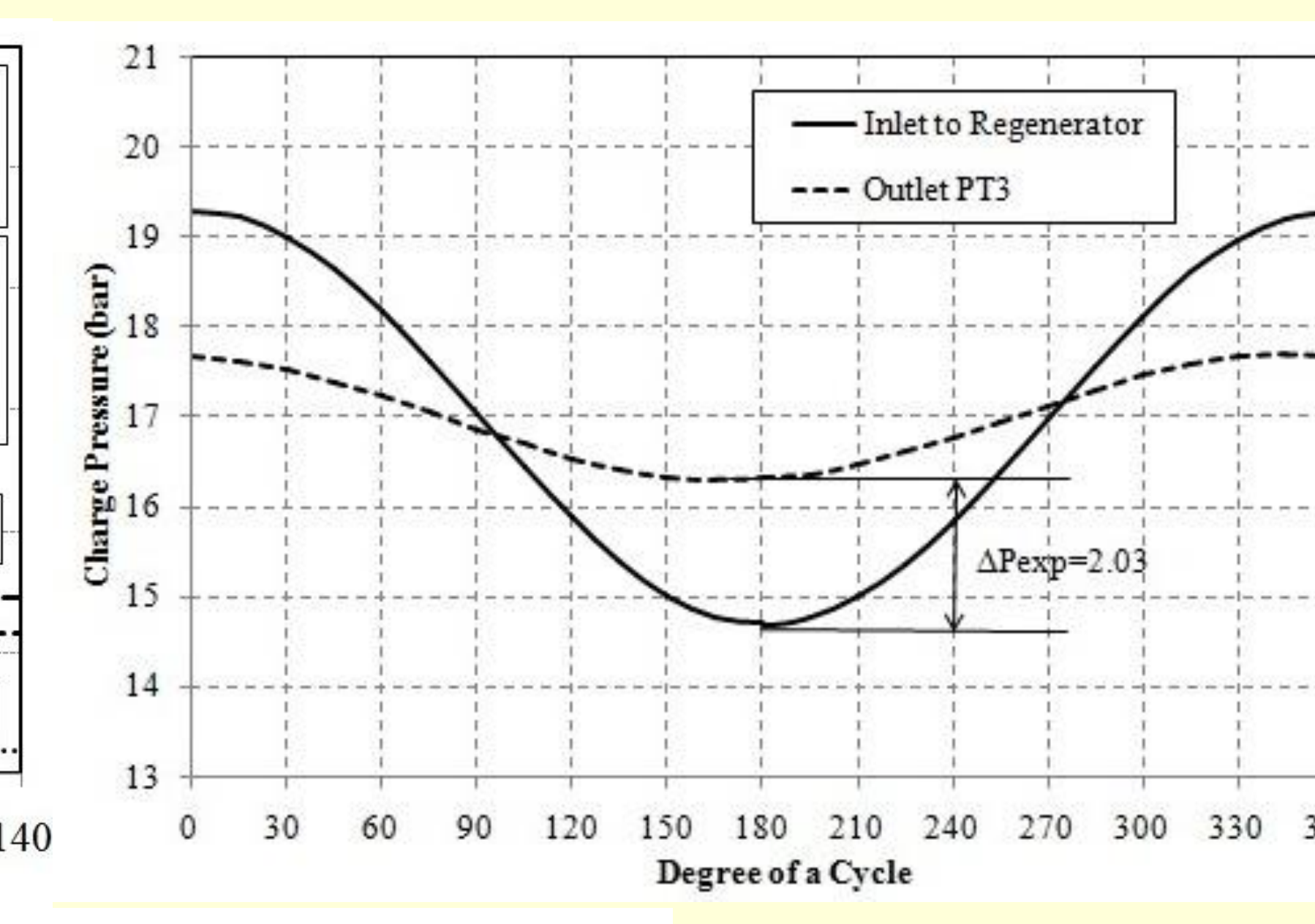
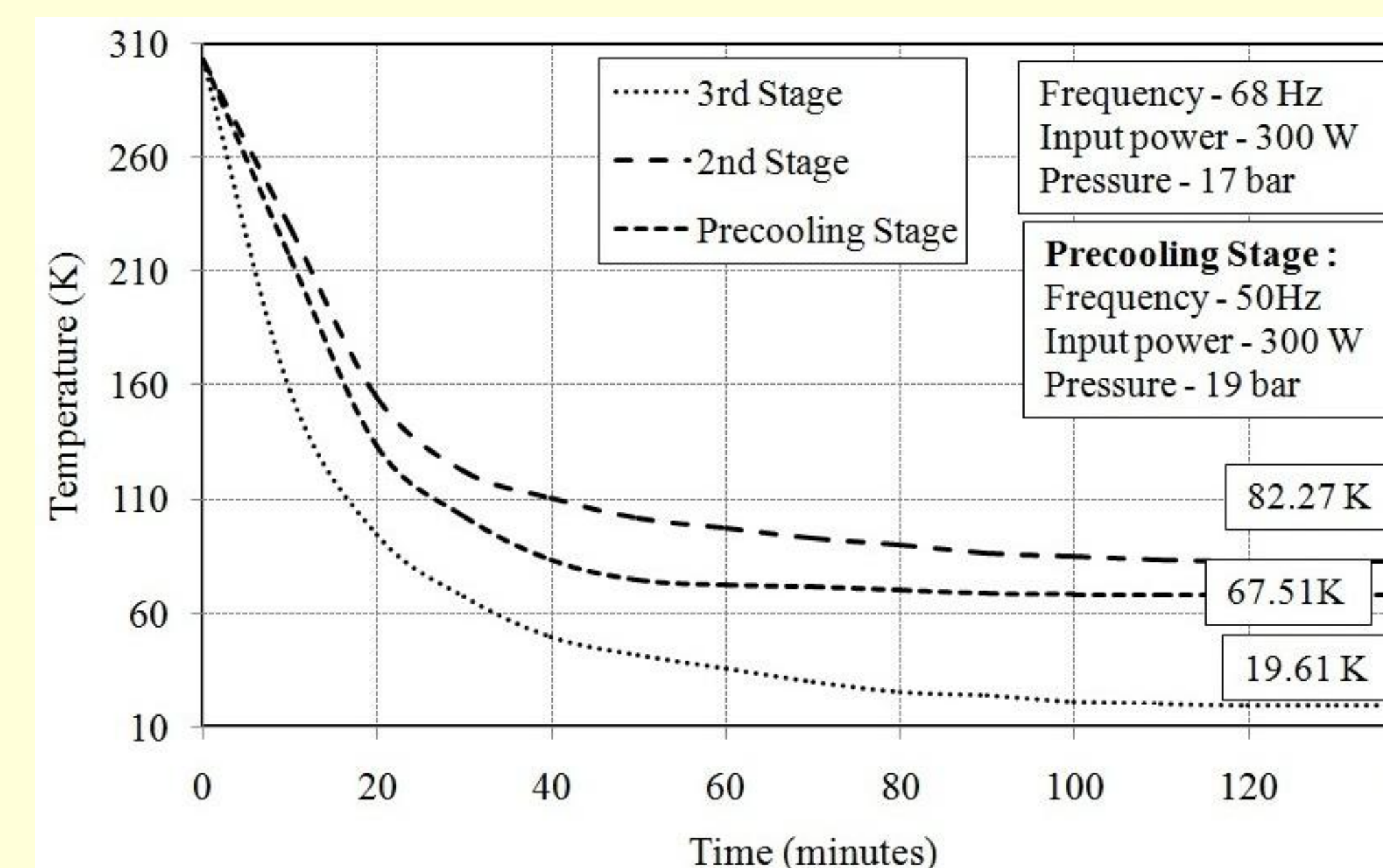
RESULTS & DISCUSSIONS



Case-1

$T_{min} = 50.07$ K
Cooldown Time = 230 min.
Pressure drop = 2.65 bar

Case-1: Two stage as Precooling Stage



Case-2

$T_{min} = 19.61$ K
Cooldown Time = 120 min.
Pressure drop = 2.03 bar

Case-2: Single stage as Precooling Stage

CONCLUSION

- ✓ In case-1 the PTC has underperformed, due higher pressure drop in the third stage of the PTC and also due to inefficiency in heat transfer between the thermal coupled stages.
- ✓ A minimum temperature of 19.61 K is achieved at third stage cold end of the pulse tube for operating parameters of 17 bar charge pressure and operating frequency of 68 Hz in case-2.

REFERENCES

- Badgular A.D., and Atrey M.D., 2011, Theoretical and Experimental Investigations of Flow Straighteners in U type Pulse Tube Cryocooler. Cryocooler 16, 211-217.
- Badgular A.D., and Atrey M.D., 2011, Experimental Investigations on Stirling type Two stage Pulse tube Cryocooler with U type Configuration. Indian Journal of Cryogenics 36, 126- 130.
- Badgular A.D., and Atrey M.D., 2014, Experimental Theoretical and experimental investigations on Stirling-type pulse tube cryocoolers with U-type configuration to achieve temperature below 20K. In Press Proc IMechE Part C: J Mechanical Engineering Science 0(0), 1-10.
- Qui L.M., Cao Q., Zhi X.Q., Gan Z.H., and Liu Y., 2011, A three stage Stirling pulse tube cryocooler operating below the critical point of helium-4. Cryogenics 51, 609-612.
- Qui L.M., Cao Q., Zhi X.Q., Han L., Gan Z.H., Yu Y.B., Liu Y., Zhang X.J., Pfothenauer J.M., 2012, Operating characteristics of a three stage Stirling pulse tube cryocooler operating around 5 K. Cryogenics 52, 382-388.
- Zhi X.Q., Han L., Dietrich M., Gan Z.H., Qiu L.M., and Thummes G., 2013, A three stage Stirling pulse tube cryocooler reached 4.26 K with He₄ working fluid. Cryogenics 58, 93-96.

INSTRUMENTATION

Pressure Wave Generator (PWG):
CHART Inc.

DI valve:
Swagelok (SS-4MG-MH)

Dynamic Pressure Measurement:
Piezoresistive transducers
ENDEVCO make

Temperature Measurement:
Silicon diode

EXPERIMENTAL SETUP

