Development of High-capacity Single-stage GM Cryocoolers at SHI

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- Scotch-yoke-driven Single-displacer GM cryocooler
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Introduction

- Applications including HTS superconducting motor, power transmission line and power generator are usually considered to consume 100 W to 10,000 W cooling power.
- Most of those applications are currently using direct liquid nitrogen cooling or Turbo-Brayton cryocoolers. Though having the potential to significantly reduce the cost and space requirement, current commercial GM cryocoolers lack the suitable cooling power which is crucial in HTS applications.
- Since 2013, Sumitomo Heavy Industries, Ltd. (SHI) has been developing high capacity single stage GM cryocoolers for HTS applications around 80 K.
- GM cryocoolers with a conventional scotch-yoke-driven single-displacer, a dual-displacer and a pneumatic dual-displacer were developed.

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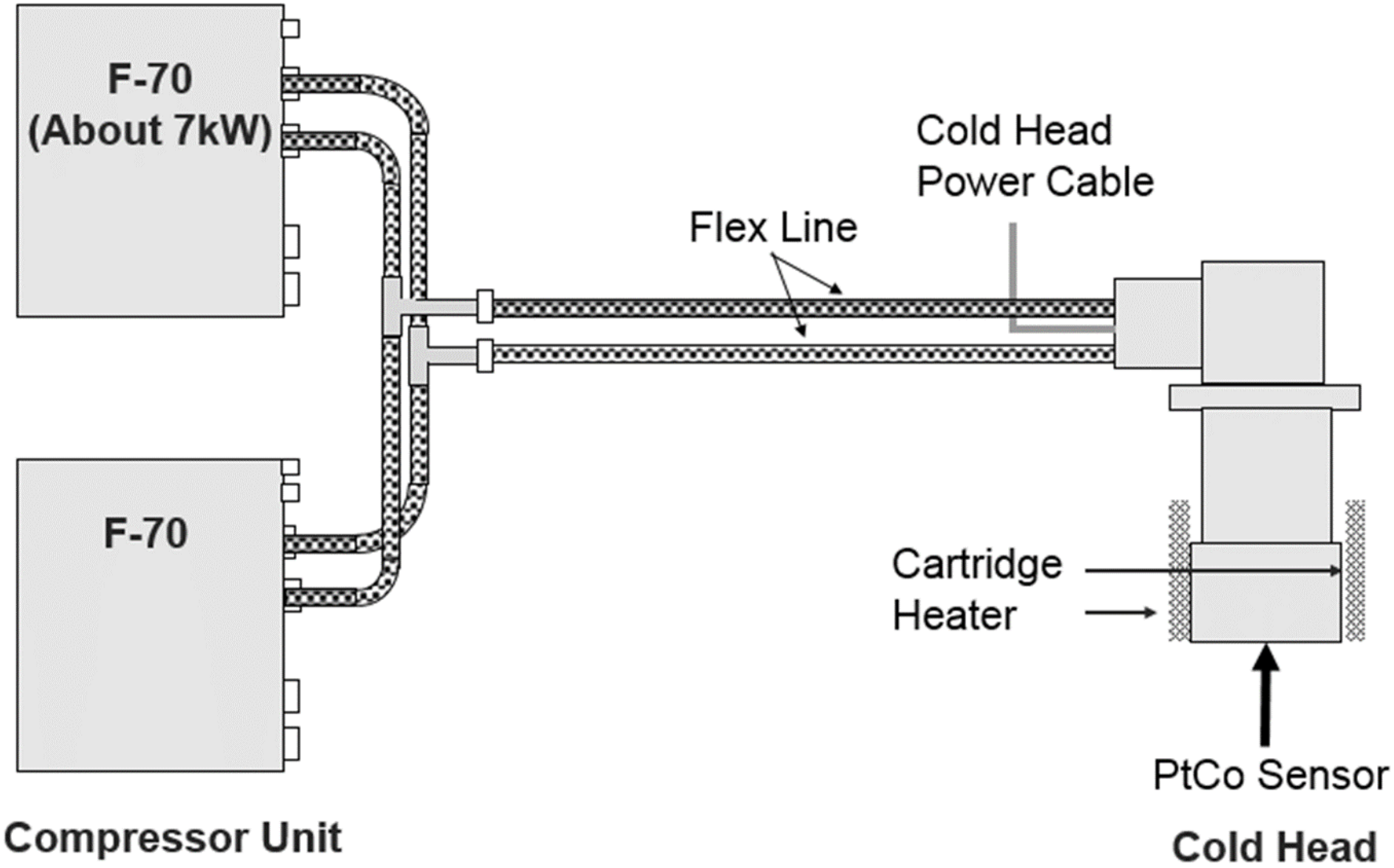
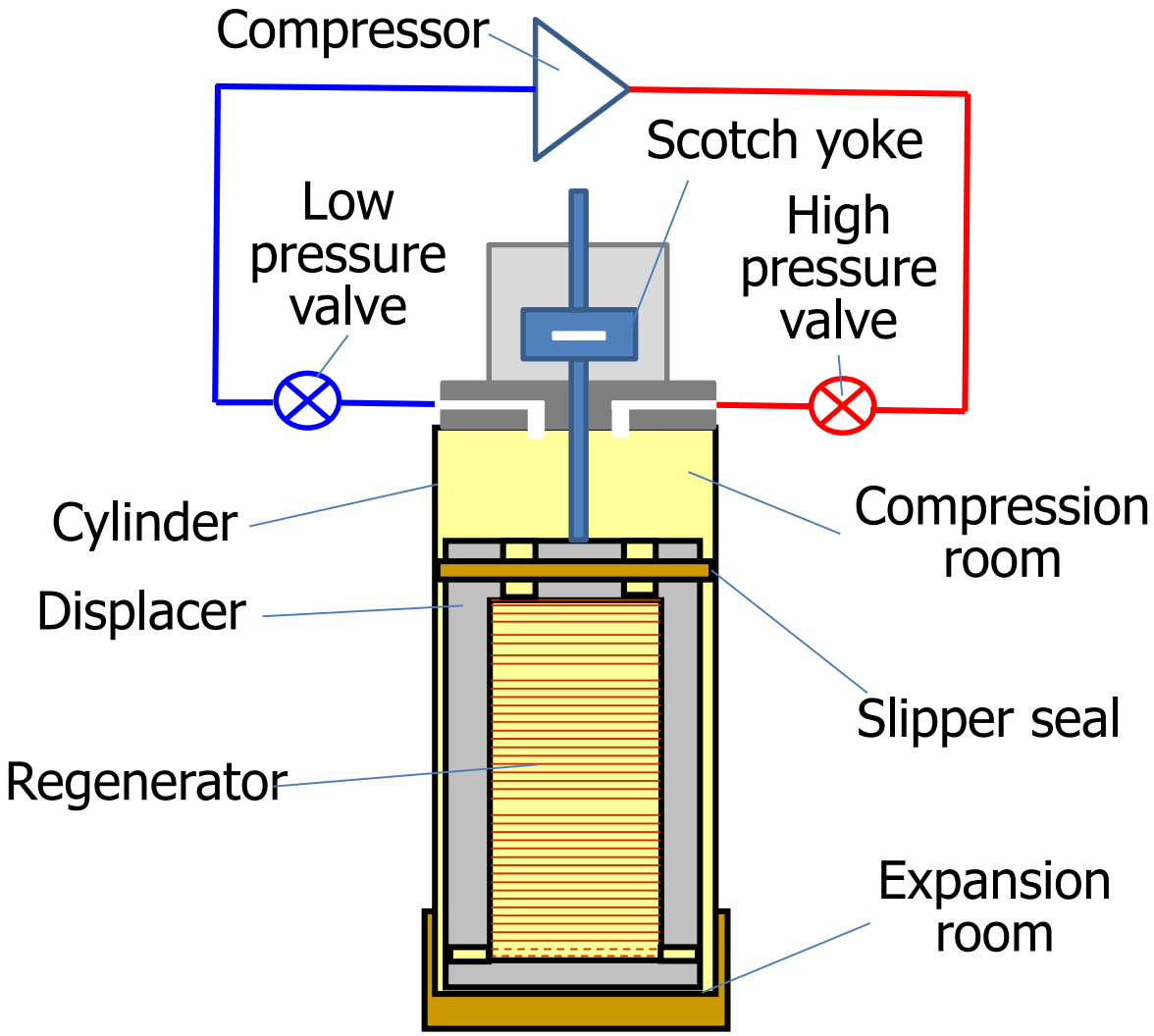
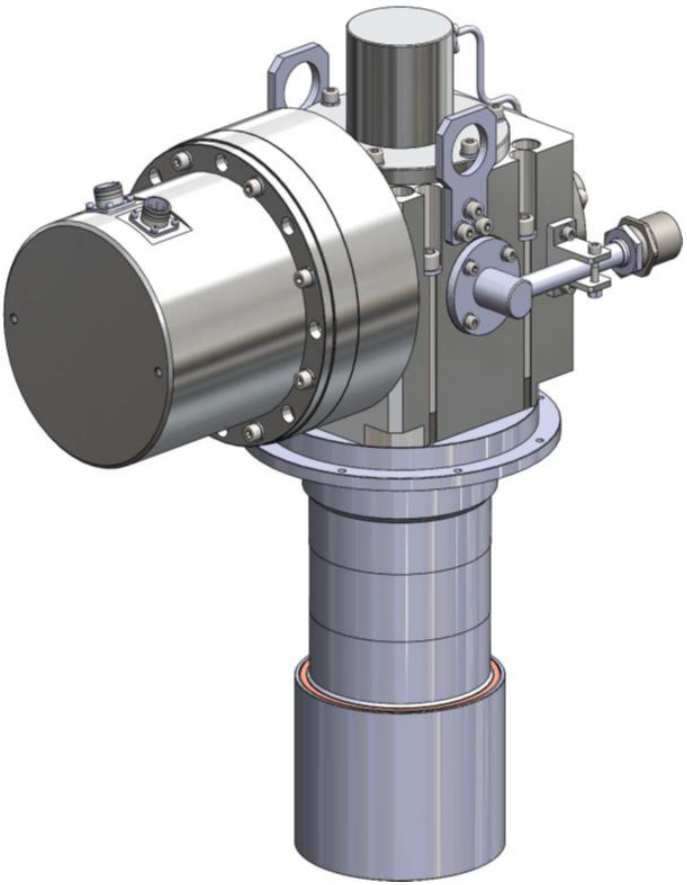
Single-displacer GM Cryocooler

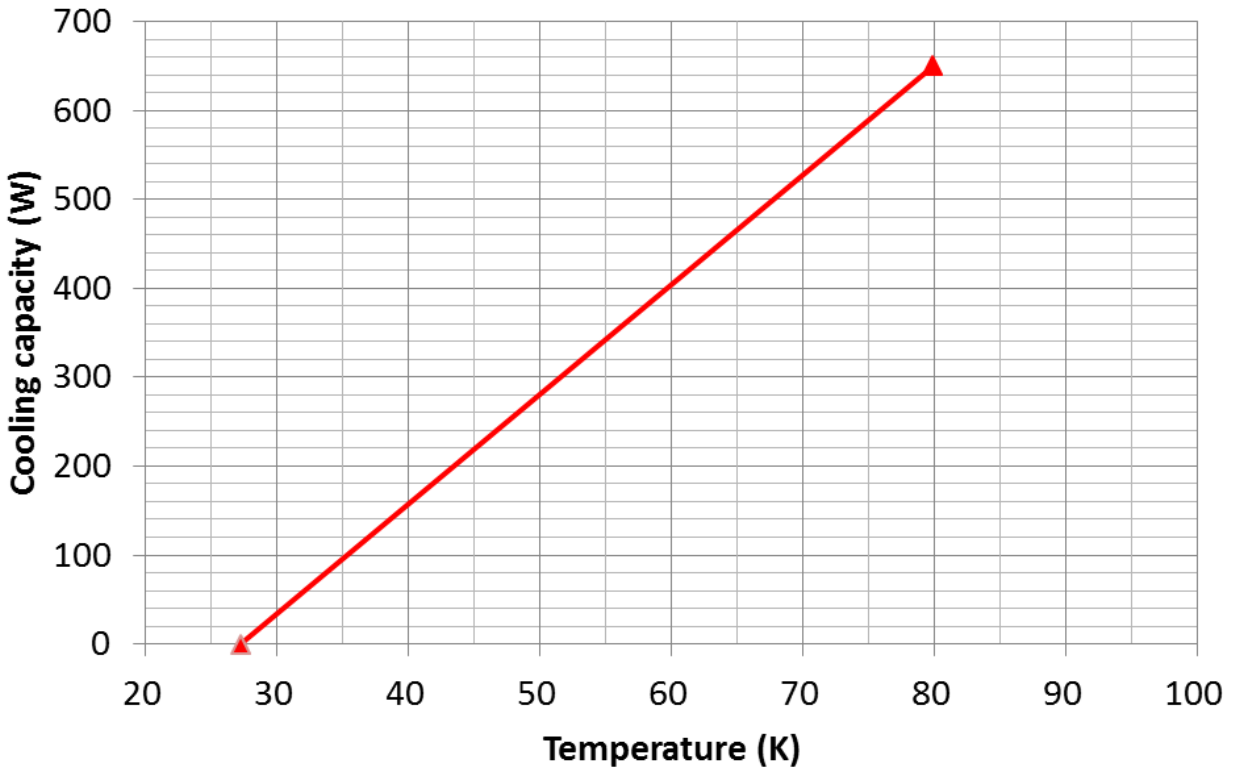


Schematic



Cooling Performance





- a cooling capacity of **650 W** was achieved with an input power of about 13 kW

Bao Q, Xu M Y and Yamada K, Cryocoolers 19 (2016), pp.

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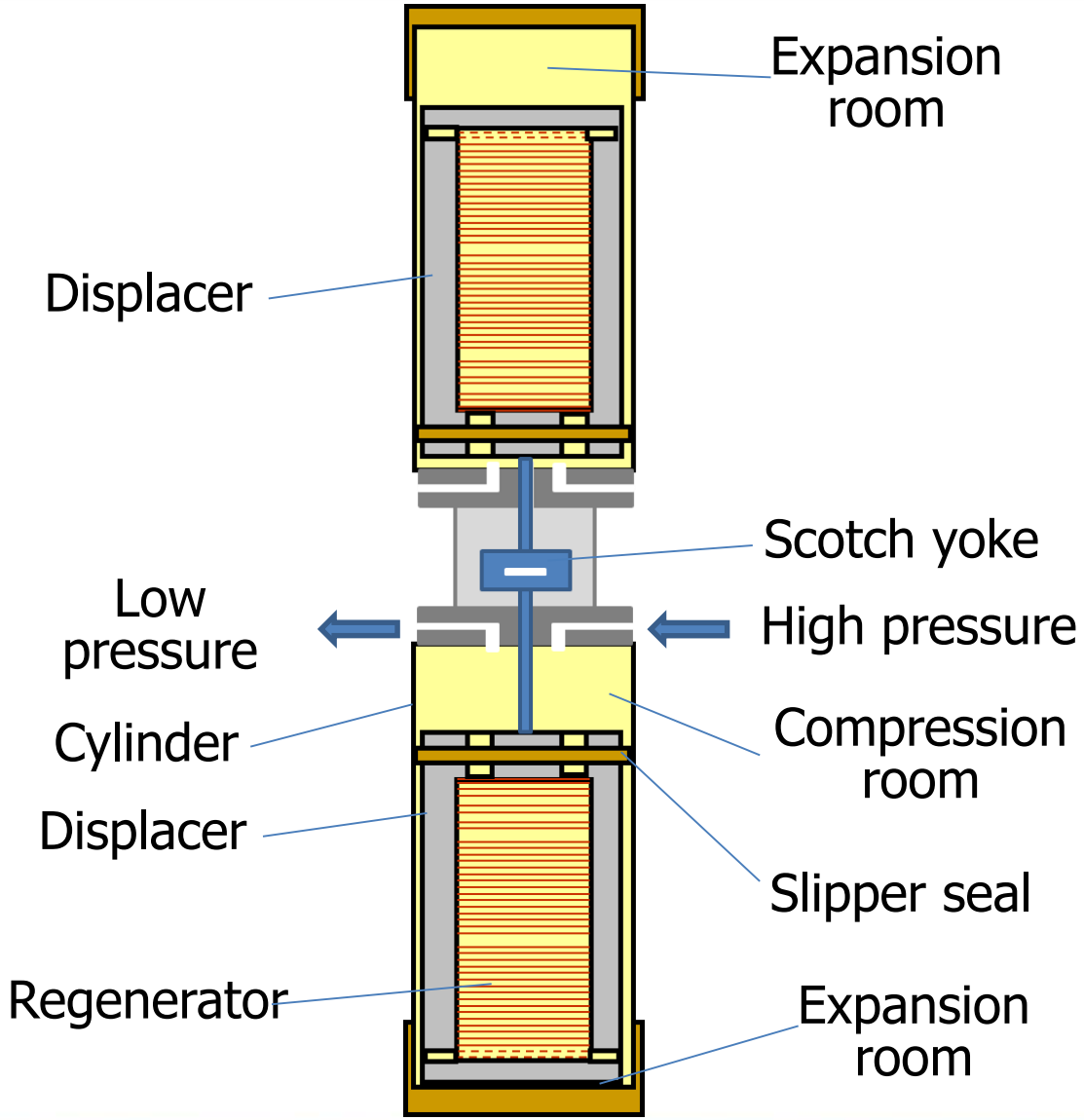
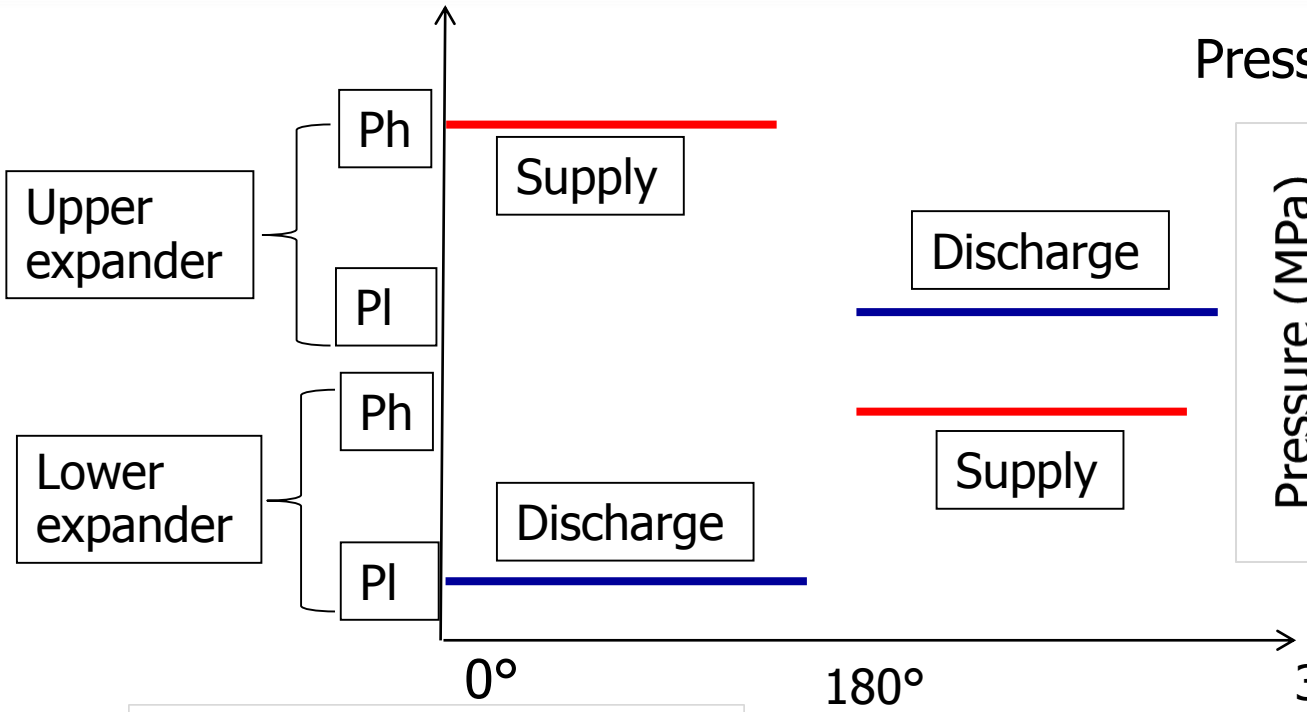
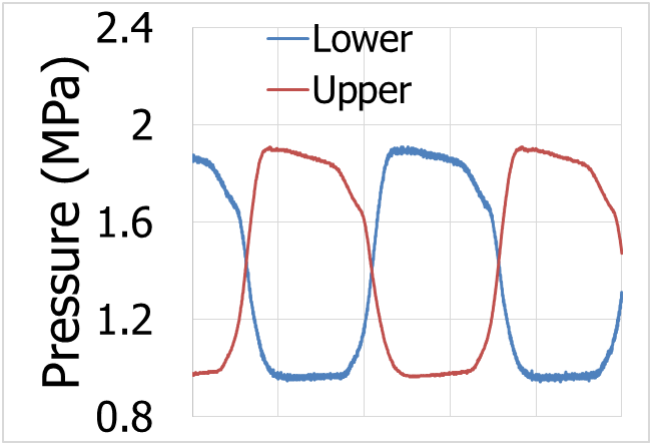
Scotch-yoke-driven Dual-displacer GM Cryocooler

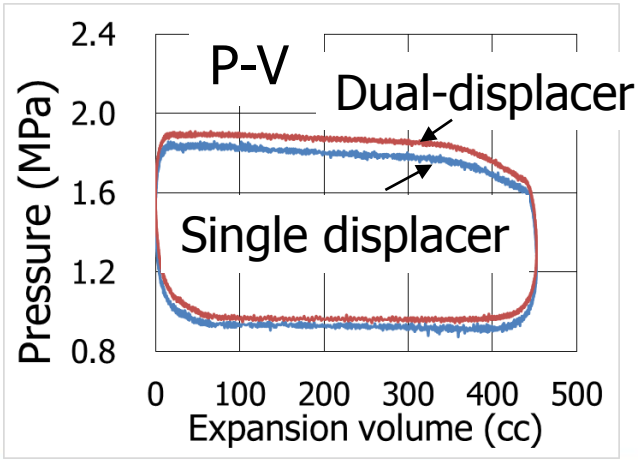


Valve timing, Pressure and P-V Power



Pressure in expansion rooms

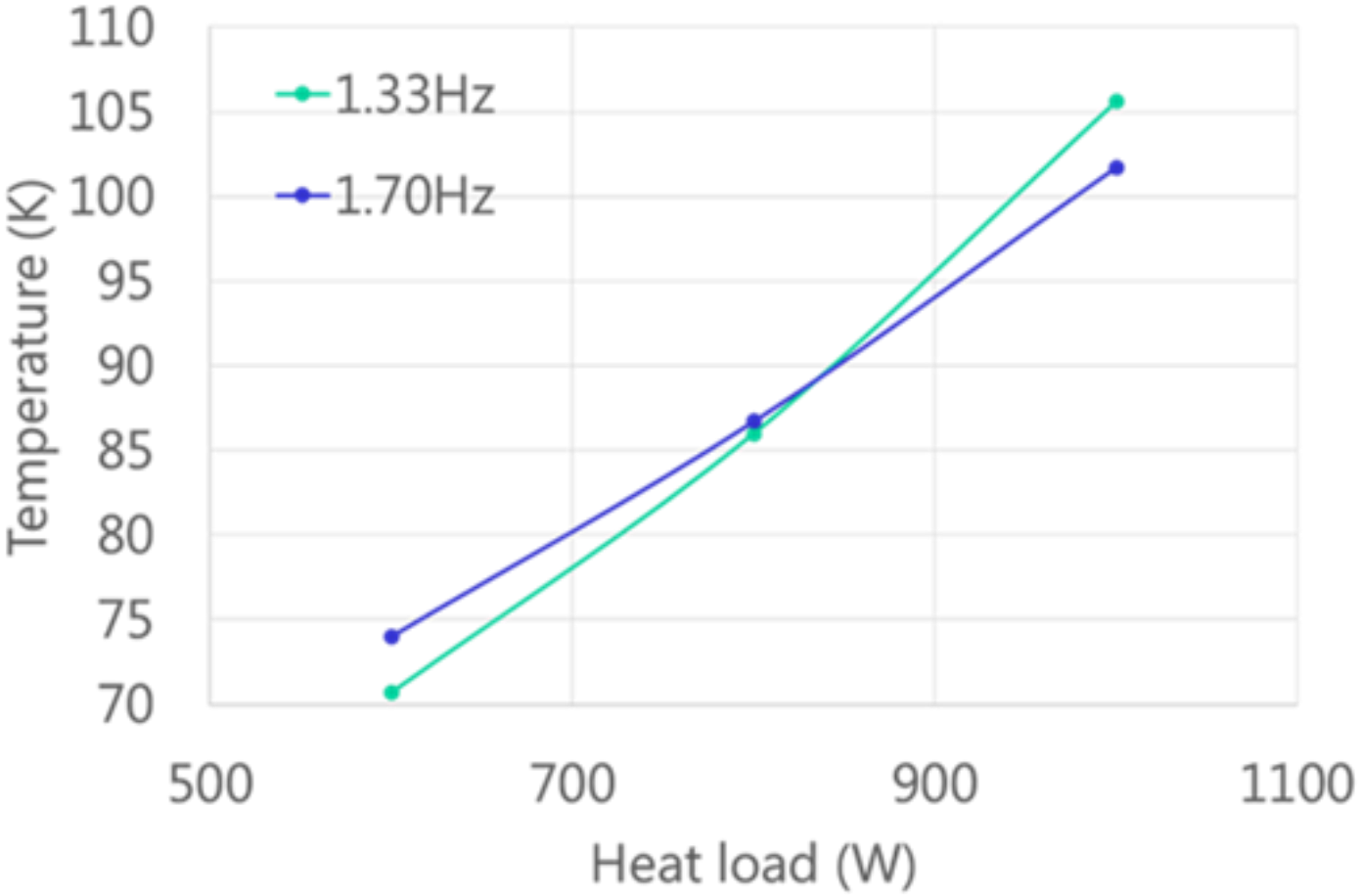




- Conventional GMx2
  494W@80K/13.5kW
- Dual-displacer GMx1
  560W@80K/13.5kW

Cooling capacity **66W** up, efficiency **13%** up

Cooling Performance



- After optimization, a cooling capacity of **725W**@80K was achieved with an input power of 13.8 kW

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Pneumatic Dual-displacer GM Cryocooler

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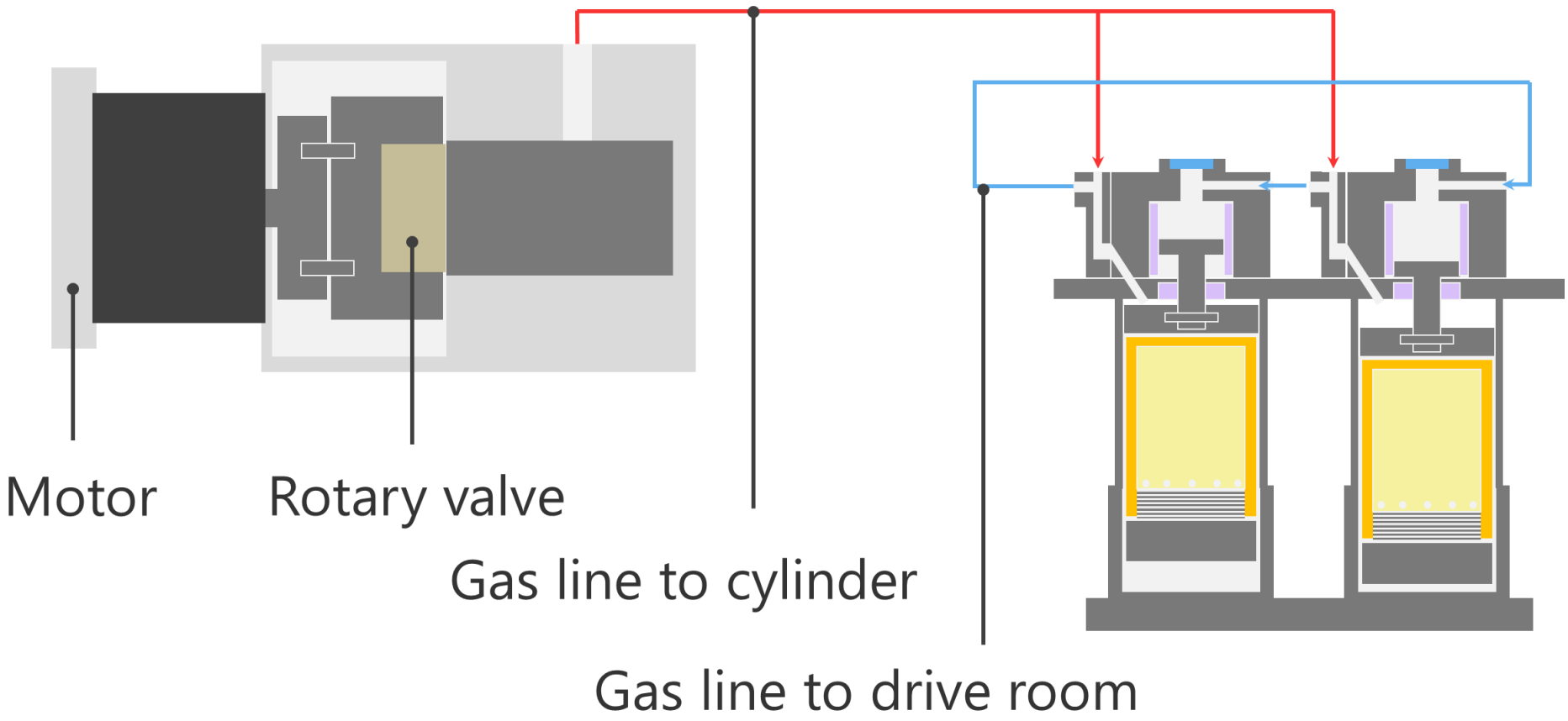
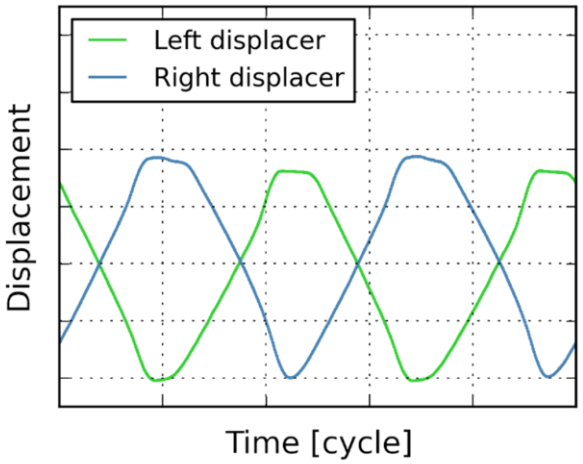
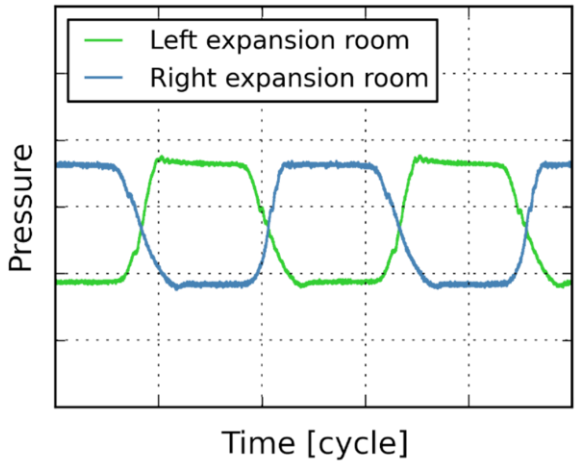
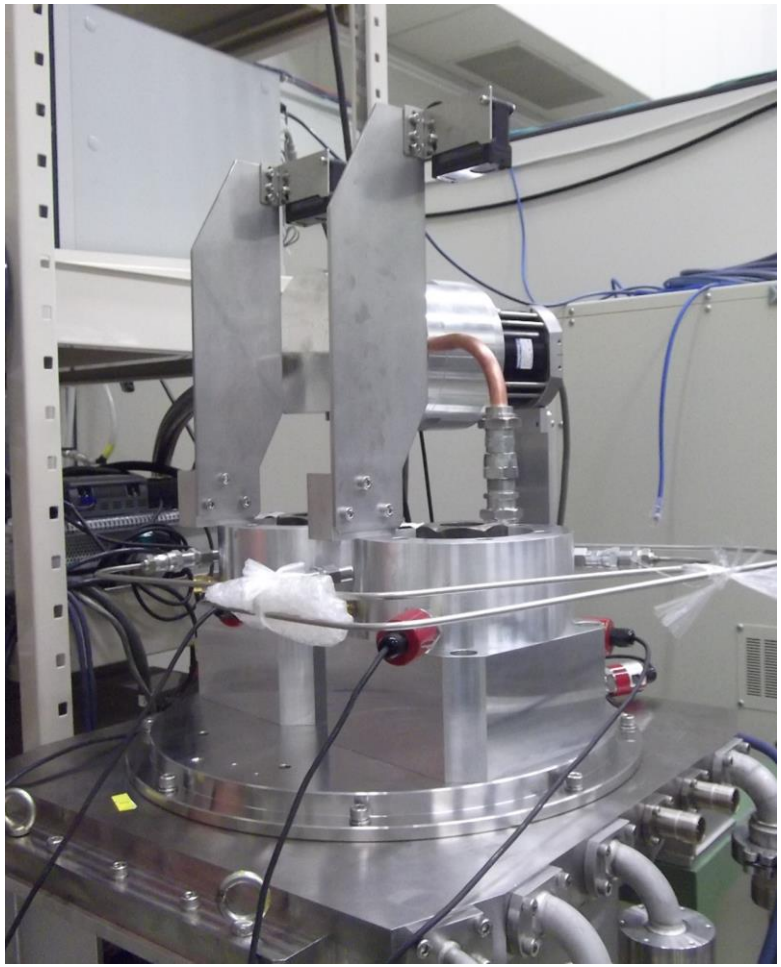


Pressure, Displacement







・a cooling capacity of **700 W** at 80 K was achieved with an input power of 18.0 kW.

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Conclusions

- With a conventional scotch-yoke-driven single-displacer GM cryocooler, a cooling capacity of **650 W** was achieved with an input power of about 13 kW.

- With a scotch-yoke-driven dual-displacer concept, a cooling capacity of **725 W** at 80 K was achieved with an input power of 13.8 kW.

- With a pneumatic dual-displacer concept, a cooling capacity of **700 W** at 80 K was achieved with an input power of 18.0 kW.

Thank you!