Design of an improved high-cooling-power 4.2 K stage G-M cryocooler and helium compressor

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NEW!

DE215S COLD HEAD (pneumatic-drive)
1.75 W @ 4.2 K, Min. Temp. < 2.7 K

ARS-20 HELIUM COMPRESSOR
Contents

1. Introduction
2. Experimental set-up
3. Test results
4. Conclusions
With broad applications in low temperature superconductor, magnetic resonance imaging (MRI), infrared detector and cryogenic electronics, the development of a high performance 4.2 K two stage cryocooler is of great importance.

Given the specific demands of some of these applications—for example, MRIs run 24 hours a day, 365 days per year—the 4.2 K two stage cryocooler’s cooling efficiency, stability, reliability and service life are critical factors.
Pneumatic-drive
Advanced Research Systems, Inc.

**2013**
- DE210S cold head (ARS-10 comp.)
  - 0.8 W @ 4.2 K, Min. Temp. < 3.0 K

**2014**
- DE210SG cold head (ARS-10 comp.)
  - 1.10 W @ 4.2 K, Min. Temp. < 2.7 K
- DE215S cold head (ARS-10 comp.)
  - 1.50 W @ 4.2 K, Min. Temp. < 2.7 K

**2015**
- DE215S cold head (ARS-20 comp.)
  - 1.75 W @ 4.2 K, Min. Temp. < 2.7 K
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FIGURE 1. Schematic diagram of the experimental setup.
Two options!

FIGURE 2. DE215S coldhead outline drawing
Regenerator materials

FIGURE 3. Regenerator packing methods.

1st stage regenerator

Hot end

Copper meshes

Pb

Cold end

2nd stage regenerator

Hot end

Pb

Rare-earth materials

Cold end
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FIGURE 4. Plots of minimal temperatures of second stage as a function of operation speed.

Min. Temp. : 2.46 K
**Displacer stroke and operation speed**

**FIGURE 5.** Plots of second stage cooling power as a function of temperature (driven by ARS-10).
**Initial charge pressure**

![Graph showing minimal temperatures of cold head as a function of charge pressure]

**FIGURE 6.** Plots of minimal temperatures of cold head as a function of charge pressure.
**FIGURE 7.** Plot of second stage cooling power at 4.20 K as a function of charge pressure.

*Initial charge pressure*
**FIGURE 8.** Compressor outline drawings

*Input power*
**Dimensions (W x L x H):**

ARS-10: 19 x 21 x 26 in

ARS-20: 20.5 x 24.5 x 33.5 in

**Weight:**

ARS-10: 250 lb. (113 kg)

ARS-20: 390 lb. (177 kg)

**Gas flow rate (60 Hz):**

ARS-10: 118 Nm$^3$/h (300 Psi / 100 Psi)

ARS-20: 190 Nm$^3$/h (300 Psi / 100 Psi)

Note: the gas flow rate is converted into values at atmospheric pressure (0 C)

**Motor input power (60 Hz):**

ARS-10: 7 kW (300 Psi / 100 Psi)

ARS-20: 12 kW (300 Psi / 100 Psi)
FIGURE 9. Comparisons of second stage cooling powers driven by ARS-10 and ARS-20 Comp.
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A high efficiency 1.5 W/4.2 K pneumatic-drive G-M cryocooler has recently been designed and developed by ARS. A typical cooling power of 1.50 W/4.2 K has been achieved driven by ARS-10 compressor. A maximal cooling power of 1.75 W/4.2 K has been achieved driven by new developed ARS-20 compressor in test runs.

The displacer stroke and operation speed are both critical to the design of the 4.2 K stage G-M cryocooler.

The life-time tests on the ARS-20 compressor and DE215S cold head are on the way.
Thanks for your attention!