HEC Pulse Tube Cooler Performance Enhancement

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ABSTRACT

The High Efficiency Cooler (HEC) space flight cooler performance has been extended both at lower temperatures (<40K) and at higher temperatures (>140K) with higher cooling powers. The 21 flight coolers delivered to date were configured for each of their payloads with customized linear and coaxial one and two temperature cold heads. The one temperature cold head requirements ranged down to 40K and in the case of the 2 stage coolers, upper temperature requirements ranged as high as 140K. Recently the need for higher cooling power coolers below 40K and above 140K has motivated us to develop pulse tube cold heads to address these requirements. In both cases only the cold heads are changed and are variants of existing designs that can be integrated with the existing flight proven compressor and flight drive electronics. As a consequence these higher capacity coolers have similar low masses (<5.5kg) to the existing flight coolers.

The low temperature cooler performance has been extended to <40K. The high temperature 4.1 kg cooler performance at 140K can be substantially increased from its current 25W capability. The performance of both these coolers will be reported

INTRODUCTION

This paper reports on development tests on 1 and 2 stage coaxial cold head versions of our HEC flight cooler[1].The one stage cooler that is reported in this paper is a variant of the HEC flight coolers (Figure 1) previously delivered for the Japanese Advanced Meteorological Imager (JAMI) payload launched in 2005, the Thermal And Near Infrared Sensor for Carbon Observations (TANSO) payload launched on the GOSAT satellite in 2009. This integral configuration pulse tube cooler contains a vibrationally balanced compressor driving a coaxial pulse tube cold head. The two stage cooler uses the same compressor with a two stage parallel cold head configuration. The parallel configuration allows flexibility in the distribution of between the stages. The efficiency of the low temperature stage is improved due to the heat strapping between the stages

Figure 1. Single Stage HEC cooler with Coaxial Cold Head

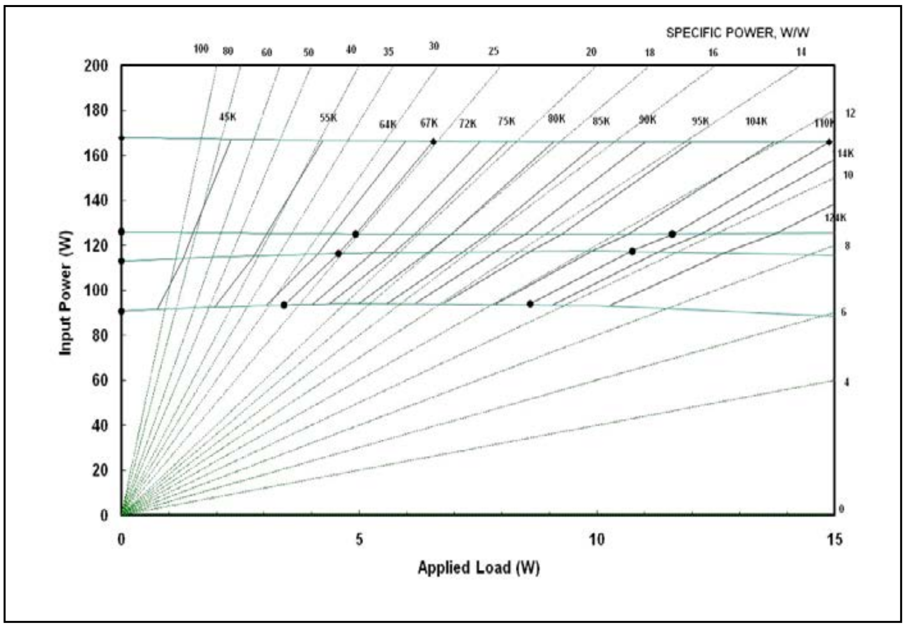


Figure 2. Coaxial HEC cooler performance map

SINGLE STAGE COAXIAL HEC COOLER PERFORMANCE AT HIGH COOLING LOADS AND HIGH TEMPERATURES

The single stage coaxial HEC cooler shown in Figure 1 was tested at input powers up to 180 Watts. To adapt the linear cold head interface to the coaxial cold head interface, an interface plate was attached to the TRL9 HEC compressor. Figure 2 gives a map of input power to the compressor vs. cooling power with interpolated isotherms (lines of constant temperature) and lines of constant specific power (input power/cooling power) overlaid over the measured data points. The performance map shown is for a 300 K reject temperature. The cooler was tested at compressor input powers between 80 W and 180 W. Figure 3 shows the performance of the cooler at high cooling loads. The cooler has a cooling capacity up to 25 W at 140K for an input power of 180W

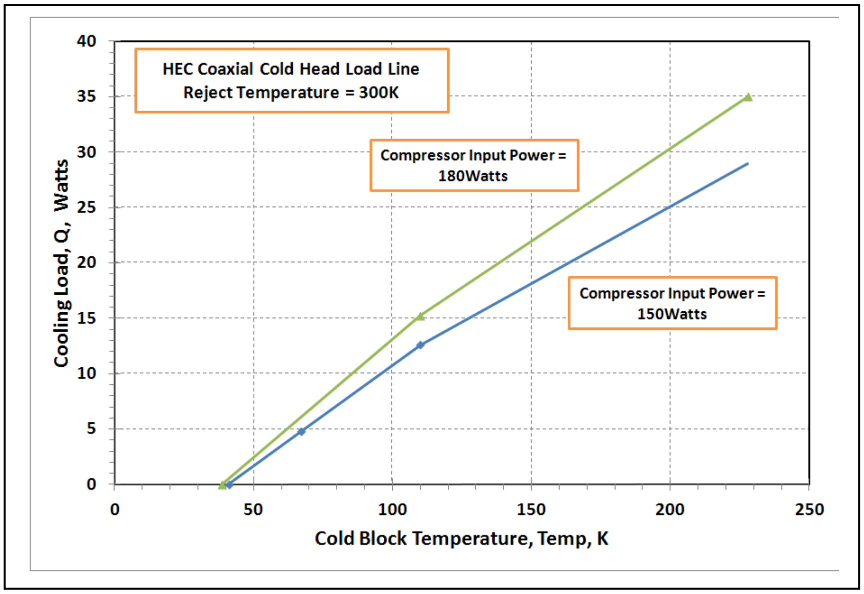


Figure 3 – Performance of the coaxial HEC cooler at high cooling loads

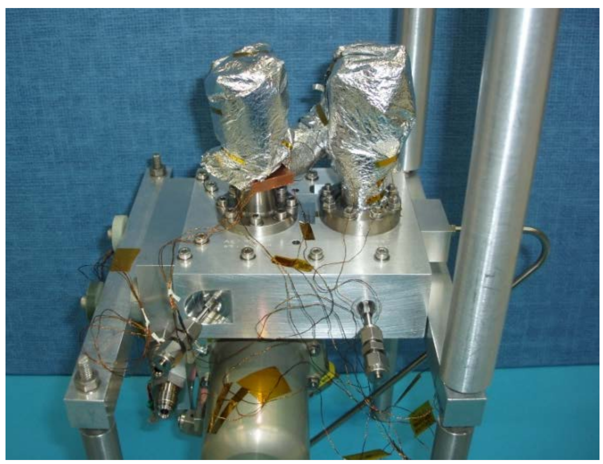
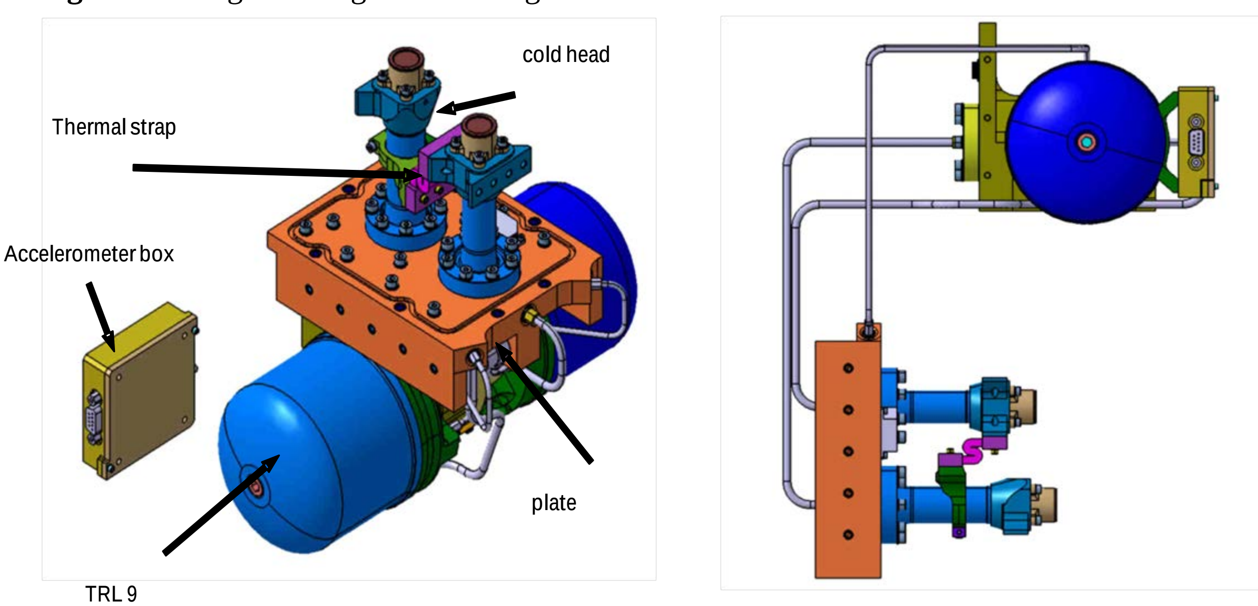


Figure 4. Integral configuration 2 stage coaxial cold head HEC in test fixture



A) Integral Configuration **B) Split Configuration**

Figure 5. 2 Stage Cooler with Coaxial Cold Heads

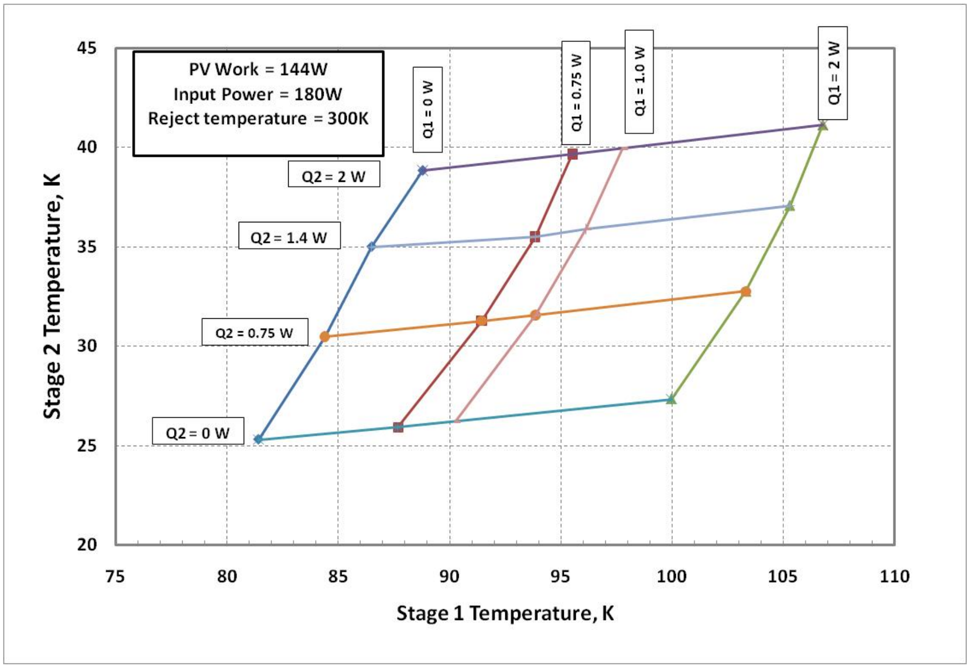


Figure 6. Performance map of the coaxial HEC Cooler at 300K reject temperature

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TWO STAGE COOLER PERFORMANCE

The 2 stage coaxial HEC cooler that is shown in its test setup in Figure 4 was tested at input powers up to 180 Watts. This integral configuration cooler was configured by adapting the existing TRL 9 HEC compressor to the dual coaxial cold heads with an interface. This tested integral configuration is illustrated in Figure 5A. Should a split configuration be required for a particular payload requirement, the interface plate and cold heads could be remotely located as shown in Figure 5B. The 2 cold heads are configured in a parallel configuration with a heat strap between the 1st stage cold block and the 2nd stage regenerator to improve its efficiency. Figure 6 shows a performance map of the 2 stage HEC cooler which plots at constant input power the temperature of the 2^{nd} stage vs. the temperature of the first stage. Lines of constant cooling power for the first and second stage are drawn on the map. A cooling load of 1.55W at 35K was measured for a compressor input power of 180W. The 2 stage HEC cooler configuration extends the cooling capacity of this flight proven cooler to 35K and below.

Performance of the 2 stage cooler has been optimized over a wide range of frequency from 51 Hz to 63 Hz. Figure 7 shows that the cooler can be tuned to maintain a constant cooling capacity over the range of frequency tested. The wide range of frequency of operation will allow flexibility in design of the payload

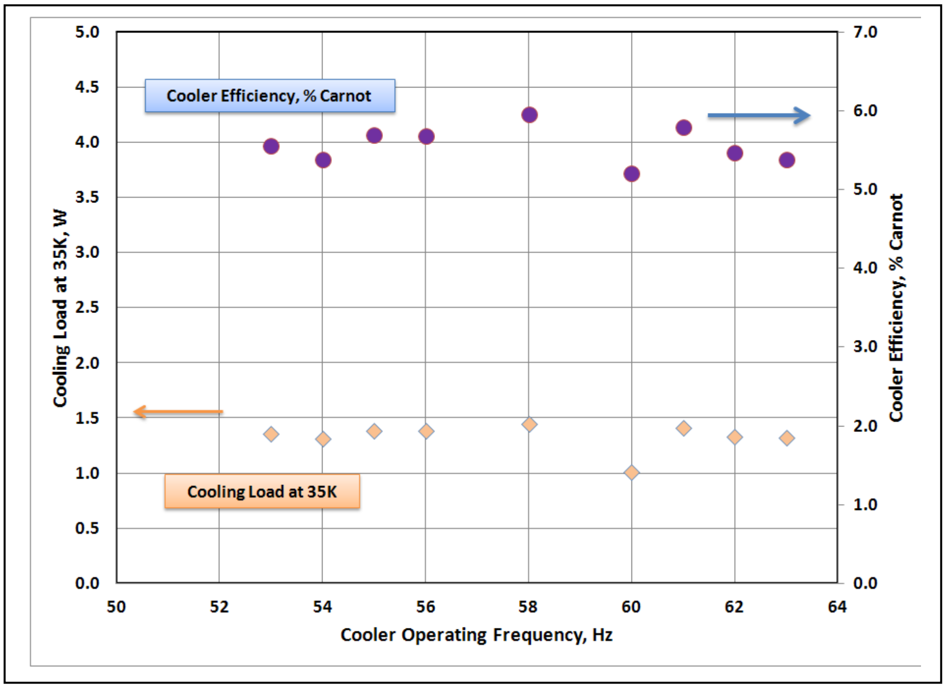

Figure 7 – Performance of 2 stage HEC cooler over a wide range of frequency

CONCLUSION

The single and 2 stage coaxial HEC cooler are two additional configurations for use with the space proven HEC compressor and drive electronics. The single stage HEC coaxial cooler provides efficient cooling at temperatures of 40 K and above. It also has a high cooling capacity at temperatures of 140K and higher. The two-stage coaxial HEC cooler provides cooling loads at temperatures as low as 30 K with additional upper stage cooling for thermal shields or optics. The cooler can operate over a wide range of frequency

REFERENCES

1. Tward E., et al "High Efficiency Cryocooler" *Adv in Cryogenic Engineering*, Vol. 47B, Amer. Institute of Physics, Melville, NY (2002), pp.1077-1084

ACKNOWLEDGEMENTS

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