Development of a pneumatic GM cryocooler with dual-displacer

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As an alternative to conventional low temperature superconducting (LTS) materials, high temperature superconducting (HTS) materials have the potential to significantly reduce the cooling cost due to their higher critical temperature. Usually proportional to the physical size of the cooling object, cost reduction is especially conspicuous in large scale applications including power transmission cable and power generator. On the other hand, relatively high cooling capacity, roughly around 10^2 W to 10^4 W, remains indispensable for most cryocooler consumers in HTS area. In order to fulfill this requirement, a single-stage, dual-displacer, pneumatic type GM cryocooler has been developed at Sumitomo Heavy Industries, Ltd.(SHI).

GM type cryocoolers can be more compact and efficient compared with the currently available large-scale Turbo-Brayton cryocoolers. The main difficulty, however, is that the force needed to drive the displacer increases with the cooling capacity at the same time, which leads to the scale-up of the housing and consequently impairs the reliability of the whole system. To overcome this problem, a pneumatic type design is proposed in which the driving force is substituted by the pressure difference of helium gas. Additionally, a novel concept, called dual-displacer structure, is introduced to further increase the cooling efficiency. Since supply and discharge timing is reversed in the two expansion spaces, the pressure oscillation amplitude at the compressor side is reduced and thus the overall efficiency of the cryocooler is improved.

A prototype unit was designed, built and tested in 2016. As preliminary results, a cooling capacity of 550W at 80K was achieved with an input power of about 13 kW. Detailed design concept and performance results will be presented in this report.