Room-temperature magnetic refrigeration: from basic research to development for application

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Basic research on magnetocaloric properties of Gd-alloys and $La(Fe,Si)_{13}$-based compounds and their cooling properties in active magnetic refrigerative (AMR) refrigration have been conducted [1] to obtain basic aspects for applying magnetic refrigeration to general refrigeration technology. The magnetocaloric materials were formed into both spherical particles and thin plates appropriate to the magnetic refrigerant in the AMR-cycle. Figure 1(a) shows a primitive test apparatus for the AMR-cycle refrigeration and the AMR-unit packed with heat transfer fluid and magnetic refrigerant particles. Magnetic field removed from and applied to the AMR-unit by up-and-down motion of the unit, and heat transfer fluid moves reciprocally by a piston installed at the botttom of the unit. The maxmum temperature difference ΔT of 46 °C and the lowest cold end temperature of −11 °C were obtained by AMR-cycle operation using a single material of the Gd-alloy under a magnetic field of 1.1 tesla. Cooling properties were investigated in terms of cycle frequency, fluid displacement, ambient temperature, particle size of magnetic refrigerant, load performance and effects of multi-layered structure of materials which have different Curie temperatures (T_C). Comparison of the cases with different refrigerant materials of Gd-alloys and $La(Fe,Si)_{13}$-based compounds were also studied in experiments and numerical calculations [2]. It was revealed that the Gd-alloys are suitable for the generation of large ΔT s, in contrast to the $La(Fe,Si)_{13}$-based compounds, which exhibit good heat-load properties. Numerical calculations indicate that multi-layered structures composed of the $La(Fe,Si)_{13}$-based compounds with gradually varying T_Cs are effective at increasing the ΔT and also demonstrate good heat-load properties. Moreover, we have engaged in the system designs to reduce power consumption for driving AMR-cycle to seek higher COP. Figure 1(b) shows a new conceptual pump-less system. By rotating magnetic circuit, not only the on/off cycle of the magnetic field but also the back/forth motion of fluid flow can be operated. We will show over all our works from basic research to development for application related to the room-temperature magnetic refrigeration in the presentation.

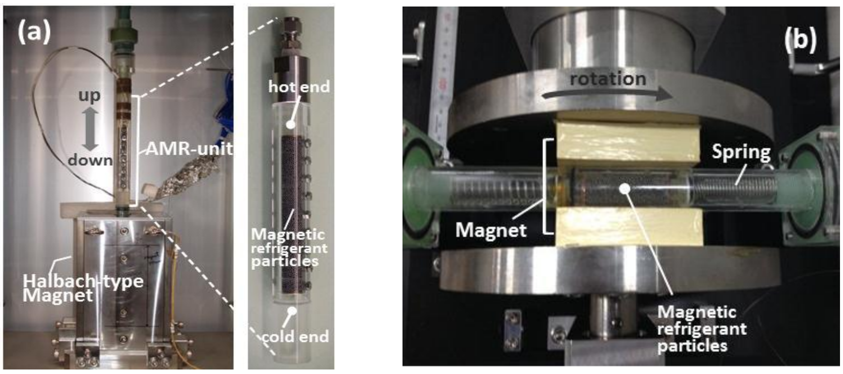

Figure 1. Pictures of (a) a primitive test apparatus of AMR-cycle and (b) a pump-less AMR-cycle system.

[1] A. Fujita, et al., *Jpn. J. Appl. Phys.* **46**, 8, L154 (2007).
[2] A. T. Saito, et al., *Int. J. Environ. Sci. Dev.* **7**, 5, 335 (2016).