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Numerical Analysis for a Continuously Operating Adiabatic Demagnetization Refrigerator (ADR) between 4.2 K and 2.0 K

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An adiabatic demagnetization refrigerator (ADR) is numerically investigated to predict the cooling performance below 4.2 K. The previous research experimentally investigated an ADR system with a passive lead heat switch for the warm end and a thermosiphon for the cold end. The warm end of the ADR, which was connected with the second stage of G-M cooler, was maintained at 5.7 K while the bottom of the thermosiphon (cold end) was always maintained at the lower temperature between 2.6 and 3.4 K as a no-load condition. In the case of heat switch for the warm side, however, the lead intrinsically has low on-off ratio due to its high operating temperature. Hence, the lead straps which have geometrically high thermal resistance did not shorten the cycle time. The newly proposed system consists of helium thermosyphon for the warm side and a magneto-resistive tungsten heat switch for the cold side. By adapting appropriate heat switching method for the warm and the cold sides, the cycle time has been significantly reduced while the passive operation of heat switches were remained. The numerical analysis was conducted with the 1-dimensional heat diffusion model considering thermal contact resistance in ADR. The calculation results show that the ADR can produce 9.2 mW cooling power at 2 K when the temperature of the warm end is maintained as 4.2 K. The detailed design methodology and the results are presented and discussed.