A 2D Piston Effect Solution for the Relaxation in the MISTE Cell

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When a large density stratification is no longer a problem in a microgravity environment, one would like to increase the sample size in order to increase the signal to noise ratio for a specific heat measurement. To reduce the equilibration time associated with the the large sample size, we designed a cylindrical cell containing a stack of plates that separate the bulk fluid into 60 equally thin layers. To understand the thermal behavior of the whole cell, we analyzed the thermal behavior of a 2D composite system of a cylindrical near-critical fluid layer in contact with a cylindrical copper plate. In this 2D analysis, the circumference boundary of the two cylindrical layers is subjected to a step temperature change. The solution of this 2D composite system includes the piston effect that speeds up the equilibration in the near-critical fluid layer and the pure diffusion in the copper plate. The results of this analysis indicates that the characteristic length for the equilibration of the stacked cell is determined by an effective thickness of a single fluid layer instead of the total height of the cylindrical cell.