In the current study, axial heat transfer enhancements by laminar oscillatory flow between cold and hot reservoirs connected by a bundle of tubes are examined experimentally and numerically. The dimensionless frequency parameter, Womersley number Wo, ranged from 0.1 to 100 with different tidal displacements. Exceeding its molecular counterpart by about five orders of magnitude, the oscillatory thermal conductivity was enhanced with quadratic scaling on the tidal displacement or pressure-gradient amplitude, and the square root of the frequency of oscillation. Two correlations were suggested for the oscillatory thermal conductivity enhancement as a function of Wo and tidal displacement. The correlations showed that the axial heat transfer rate scaled in proportion to $Wo^{1.62}$ for Wo > 3 and behaves exponentially for low Wo with different scales depending on pressure gradient amplitude. The study has proposed a classification for the oscillatory flow by partitioning the flow into four different regions varying from low tidal displacement to bulk convective exchange. The results also showed that for unsteady flow the unsteady axial conduction is negligible for Wo > 3, but becomes significant as it goes below Wo = 3. This criterion invalidates the previous studies' assumption for Wo < 3 by ignoring the unsteady axial conduction. Finally, more than ten times of enhancement in axial heat transfer rate was observed in tubes with sufficient wall thickness. This non-zero thermal diffusivity at the interface between the fluid and the tube wall has improved the storage-release process through the Stokes layer