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USING SUPERCRITICAL FLUIDS TO TRANSPORT HEAT ON LONG DISTANCES: AN ASSESSMENT

Abstract

Heat transport on large distances is classically performed by radiation and convection of latent heat (heat pipes, gravity or capillary driven). We investigate here whether the "Piston Effect" (PE), a thermal phenomenon that is very efficient in weightlessness in compressible fluids such as fluids near their critical point, could also be used to perform long distance heat transfer. The PE consists in the spatially uniform heating of the fluid bulk due to its adiabatic compression by the thin expanding hot (or cold) thermal boundary layer (BL) that forms close to the heating (or cooling) wall. A heat transport can thus be performed in the both hot and cold BL's connected by the bulk fluid that acts as a kind of thermal short circuit. While such a "heat pipe" does not work in the stationary regime, it could serve to achieve the fast transients. In this work, we aim to evaluate whether this process can be used to transport heat on large distances under weightlessness. Experiments are performed in a closed cell modelling a pipe (16.5 mm long, 3 mm inner diameter), with nearly adiabatic Plexiglas walls and two copper base plates. The cell is filled with H2 near its gas-liquid critical point (critical temperature: 33K). Weightlessness is achieved by submitting the fluid to a magnetic force that compensates gravity. Initially the fluid is isothermal. Then heat is sent to one of the bases by an electrical resistance. The heat transported by the fluid is measured at the other end. The data are analyzed and compared with a 2-D numerical simulation that allows an extrapolation to be made to other fluids (e.g. CO2, with critical temperature 300 K). The major result is concerned with the existence of a very fast response at early times that is only limited by the thermal properties of the cell material. The yield in terms of ratio: injected / transported heat power does not exceed, however, 10-20%. These results are valid in a large temperature domain, of order of 10-100 K around the critical temperature.