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Closed Loop Pulsating Heat Pipes at Variable Gravity Levels

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The demand of high heat transfer capability, coupled with relatively cheap and increasingly small components, leads to the evolution of novel two-phase passive devices both for ground and space applications. As relatively new, still poorly studied, but promising members of the wickless heat pipes family, the Pulsating Heat Pipes, with their high effective thermal conductivity, low costs and other interesting characteristics with respect to the conventional two-phase devices, are the optimum candidate suitable for particular cooling needs, such as for large foldable structures, but also for micro-systems. Despite the geometrical simplicity, the physics behind a PHP is very complex, and both experiments and numerical simulations show very challenging tasks. The thermal-hydraulic behaviour of a planar, copper tube capillary PHP (I.D. 1.1mm) partially filled with FC-72 in modified gravity conditions (0g, 1g and 2g) was tested experimentally on ground, on the ESA-ESTEC Large Diameter Centrifuge and during the 58th ESA parabolic flight campaign. A Space-PHP with a larger internal diameter, which is not capillary on ground, but it is capillary in microgravity, has also been tested and the bubble behaviour has been recorded through a high speed camera during the 61th ESA parabolic flight campaign. Furthermore, a novel one-dimensional lumped parameter numerical model for the transient thermo-hydraulic simulation of a PHP is proposed. It consists of a two-phase separated flow model applicable to a confined operating regime, meaning that capillary slug flow is assumed a priori. A complete set of balance differential equations accounts for thermal and fluid-dynamic phenomena. The originality of this numerical tool lays in the suppression of the standard assumption of saturated vapor plugs as well as in the consequent embedding of heterogeneous and homogeneous phase changes. Comparisons with the experimental results are then given, showing a breakthrough ability to model the existing Closed Loop Pulsating Heat Pipes.