Numerical Simulation of a Capillary Pulsating Heat Pipe in Various Gravity Conditions

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Extended Abstract

In the last two decades a new concept of capillary heat pipe without wick structures, commonly known as Pulsating Heat Pipe (PHP), entered the domain of the two-phase passive heat transfer devices. The thermal-hydraulic behavior of this mini-channel with alternate heating and cooling zones, evacuated and partially filled with a working fluid, mainly depends on the interplay between phase change phenomena, capillary and gravity, if present, which may assist or damp the fluid motion.

Numerous are the attempts to simulate PHPs complex behavior, but only a few of them are capable of complete thermal-hydraulic simulations; in addition, none is able to predict the effects of various gravity levels. Nevertheless, validated numerical simulations can constitute useful tools to complete and support experimental studies, and to help the design of new and better performing PHPs.

Thus, a novel lumped parameters numerical code for the transient thermo-hydraulic simulation of PHPs has been developed and validated. It consists of a two-phase separated flow model where capillary slug flow is assumed a priori. A complete set of balance differential equations accounts for homogeneous and heterogeneous phase-changes, as well as thermal and fluid-dynamic phenomena. This novel model shows a very good quantitative and qualitative prediction capability not only when computing the correct measured equivalent thermal resistance, but even when reproducing the experimental trend of temperature when transient conditions are applied (see, for example, Fig 1). This paper presents the comparison between numerical and experimental data, for a copper PHP (I.D./O.D. 1.1mm/2.0mm) filled with FC-72 tested experimentally in micro-gravity (58^{th} Parabolic Flight Campaign), and hyper-gravity conditions (ESA SYT!2013 Programme).

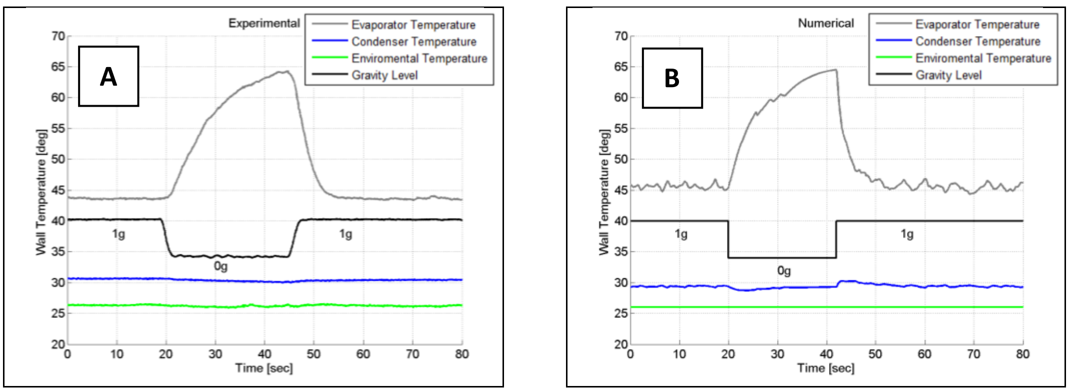

Fig. 1: a) Experimental and b) numerical comparison of the data from the 58^{th} parabolic flight.