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Sensitivity Analysis of a Capillary Pulsating Heat Pipe: Influence of the Tube Characteristics

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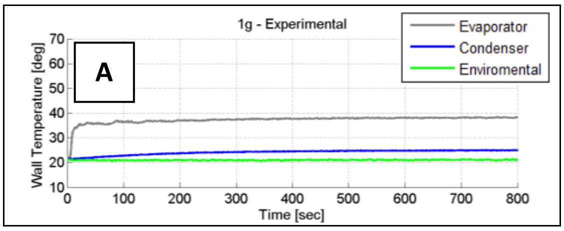
Extended Abstract

The present industry demand of high heat transfer capability, coupled with reasonably cheap and increasingly small components, leads to the evolution of novel two-phase passive devices. As relatively new and promising members of the wickless heat pipes family, pulsating heat pipes (PHPs) represent a promising and a flexible solution for quite high heat flux applications, up to 30W/cm^2.

A PHP consists of a capillary loop with alternated heating and cooling zones, evacuated and partially filled with a working fluid. Despite its relatively simple structure, the PHP thermal-hydraulic behaviour is complex, chaotic and non-linear. Up to now, very few models are able of complete thermal-hydraulic simulations, and even less are partially validated against experimental data.

In this study, a novel 1D lumped parameters numerical tool able to reproduce the performance of PHPs is described. It consists of a two-phase separated flow model which accounts for the phase changes, as well as the thermal and the fluidic phenomena that appear within a PHP when a slug flow can be assumed. This code has already been validated against experimental data both in quasi-steady state and transient conditions under various gravity levels showing good prediction capability (see an example in Fig. 1).



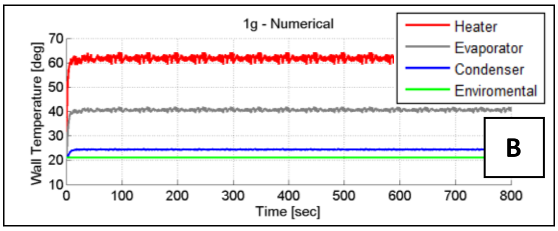


Fig 1: a) Experimental and b) numerical temperature for a ground tested bottom heated mode copper PHP filled with FC-72 (0.5 volumetric filling ratio) when 3.23W/cm^2 are provided in the hot region.

This paper shows the influence of the tube characteristics on the global performance of a planar PHP filled with FC-72 for different values of flux provided in the hot region. The device will be tested in vertical Bottom Heated Mode varying the wall material (e.g. copper, aluminium, PET), the tube internal and external diameter (e.g. ID/OD 1.6/2.5mm, 1.1/2mm, 0.5/1.4mm) and the number of turns in the evaporator sections (e.g. 16, 8, 4). This kind of analyses are very interesting for industries and researches, if the aim is to find ways to improve and optimize PHPs for a large number of applications belonging to different fields, from automotive and aerospace to electronic cooling and house-holding in general.