Structure proposant : CNES

Domaine / Thématique : Space Technologies

Titre du sujet : Experimental and physical characterization of Pulsating Heat Pipes for space application

Descriptif du sujet :
Thermal management of the on-board electronic components becomes one of the major issues limiting their power and effective means of heat transfer are required. Current trends are towards high-throughput and flexible geostationary satellites using greater numbers of SSPAs, digital transparent processors (DTP), phased arrays, etc. This increases the on-board processing and results in greater amounts of heat rejection while lowering equipment operating temperatures. In particular, the ability to reduce the delta temperature via direct chip cooling is more effective than conduction through equipment alone and would dramatically improve rejection efficiency. Currently the existing direct chip cooling solutions utilize direct thermal conduction via PCB architecture, or sometimes with Loop Heat Pipe and/or Standard Heat Pipe technologies which results in challenging design and manufacturing constraints due to the very small pore sizes required in the wick.
Pulsating Heat Pipes (PHPs) are a beneficial alternative as they do not require complex features (no internal wick features) as it consists of a thin meandering 2-phase capillary tube (<5mm) which can be densely packed to provide high thermal performance: both high heat flux density and transport capability. Unlike the conventional heat pipe, a closed tube or channel is meandered between the evaporator and condenser thus forming multiple branches (i.e. parallel tubes) and, filled with a two-phase fluid at saturation state, is able to transfer heat between both sources. One specific variant of this technology, the Flat Plate PHP (FPPHP), is of particular interest for space applications as its very slim layout enables its accommodation inside electronic stacks.
However, the PHP functioning is highly non-stationary and also depends on many parameters (tube diameter, number of turns, respective lengths, working fluid properties, heat flux, orientation/gravity, etc.): despite the huge number of studies in literature, its behavior remains very difficult to understand and more specifically to predict.

The objectives of this new thesis are to better characterize the influence of the sizing key parameters, to further be able to size properly a PHP with regards to specific industrial applications. This extensive characterization may be performed experimentally, in order to build and feed an experimental database. Besides, a simple monotube analytic model may be sketched to help designing PHPs with a proper set of sizing parameters, with a validation step by a PHP simulation code developed by the CEA.

Profil du candidat :
The candidate's profile must match the description of the research project.
The candidate must:

- hold an Engineering or a Master's degree in physics and/or mechanics (thermal science, fluid mechanics, etc.)
- have experience in thermal management technologies (space or ground)
- have skills in experimental physics, diagnostics, measurements
- have ability to work as part of a team,
- be able to commit fully to the project, with a strong motivation for the proposed subject
- be intellectually curious, conscientious and diligent.

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