Aerospace Europe Conference 2023
Joint 10th EUCASS – 9th CEAS Conference

To be sent in pdf format

Abstract #XXX *(to be filled by the organizers)*
Preferred Topics: CFDMPS / SPEXPLO / PROPHY
Corresponding author: BORSHCHAK KACHALOV Andriy
e-mail of corresponding author: *andriy.borshchak@upm.es*
Type: Oral / Poster *(select)*
Status or corresponding author: Regular / Student *(select)*
For student corresponding author: student member of one of the following:
3AF / AAAR / AIAE / AIDAA / CzAeS / DGLR / FTF / NVvL / PSAA / RAeS / SVFW / EUROAVIA

Title

Optimizing the thermocapillary-driven melting of phase change materials in microgravity

Authors

Andriy BORSHCHAK KACHALOV, Pablo SALGADO SÁNCHEZ, Dan GLIGOR, Úrsula MARTÍNEZ, José Miguel EZQUERRO, Jeff PORTER*

** Corresponding author*
Spanish User Support and Operations Centre (E-USOC), Center for Computational Simulation (CCS), Universidad Politécnica de Madrid (UPM), Madrid, Spain, andriy.borshchak@upm.es

Abstract

Phase change materials (PCMs) are attractive solutions for energy storage and thermal management in numerous applications. Space missions, which generally operate in weightless environments, represent a special area of application where PCMs can be used as part of active or passive systems. However, common organic PCMs have low thermal conductivity, which results in a slow heat transfer rate, and, together with problems of high pressure from volume changes and the inconvenient formation of bubbles (voids) during melting, this has discouraged their wider use. Recently, various studies have suggested that, if the PCM device incorporates a free surface, the temperature distribution inherent to its operation will drive thermocapillary convection in the liquid phase and thereby substantially improve the rate of heat transfer and overall PCM efficiency. Simultaneously, the presence of a gas layer helps alleviate the problems associated with thermal expansion. Following the pioneering parabolic flight experiments of Ezquerro et al. [1, 2], a series of investigations have analyzed the thermocapillary-driven melting of PCMs in rectangular domains [3, 4]. Although there is a significant overall positive effect of thermocapillary flow on the heat transfer rate, the phase change process also includes a final stage that is dominated by conduction, where the PCM near the cold boundary melts slowly. This final stage sets a certain lower bound on the melting time and reduces the overall PCM performance. In the recent work of Ref. [5], the use of trapezoidal and triangular containers created by inclining the cold boundary was proposed to accelerate the melting process. It was shown that, compared to the rectangular case, the total melting time can be reduced by a factor of 3 in the limiting configuration of a right triangle. In this work, we extend these efforts and propose a novel type of triangle-like container with a curve in place of the hypotenuse. We define this curved boundary using a third-order polynomial that preserves the total PCM volume. Results indicate that this modified geometry can further accelerate melting, with an optimal additional improvement factor of 1.2 observed in short containers.

References

[1] J. M. Ezquerro et *al*. *Acta Astronautica* **162**, 185-196 (2019).
[2] J. M. Ezquerro et *al*. *International Communications in Heat and Mass Transfer* **113**, 104529 (2020).
[3] P. Salgado Sánchez et *al*. *International Journal of Heat and Mass Transfer* **163**, 120478 (2020).
[4] P. Salgado Sánchez et *al*. *Journal of Fluid Mechanics* **908**, A20 (2020).
[5] A. Borshchak Kachalov et *al*. *International Journal of Heat and Mass Transfer* **185**, 122427 (2022).