ELECTROWAVE

ELECTROWetting heat pipes for cooling Applications in Electric Vehicles

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Total Approved Funding (PT): €98 475
Total approved Funding (UT Austin): $48 420

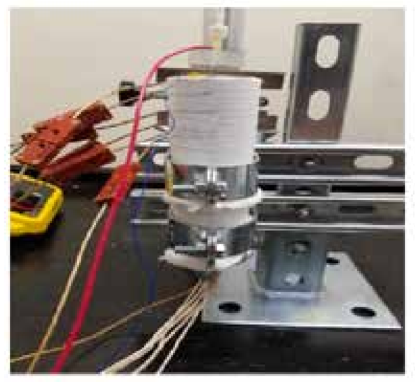
NANOTECHNOLOGIES

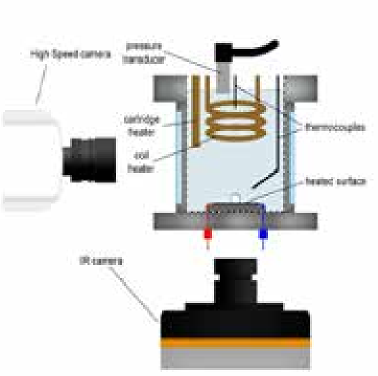
Background

The Electrowetting Heat Pipe (EHP) is a new cooling technology capable of transporting high heat loads over long distances. The working fluid evaporates in the evaporator (which is in contact with the heat source), thereby removing heat. This vapor then condenses in the condenser (cold region) and the condensate is returned to the evaporator. Conventional heat pipes are limited in their ability to transport high heat loads over long distances.
The EHP solves this issue acting disruptively in two ways: i) using electrowetting-based pumping to move the condensate back to the evaporator, and ii) utilizing electrically enhanced evaporators to enhance heat transfer and prevent dryout in the evaporator. In this project, the heat transfer enhancement in the evaporator is studied via experiments and numerical analysis.

Approach/Methodology

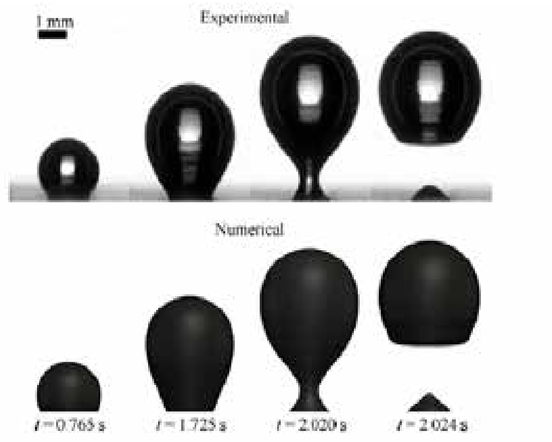
The main activities were divided in two major tasks. The first task explored a novel concept for enhancing the performance of the evaporator of the heat pipe. The evaporator section of the heat pipe absorbs heat and determines the thermal performance to a significant extent. This task involved experiments and analysis at UT Austin, focusing on the film boiling regime. Portuguese team at IST-ID focused on the evaporator trying to extend the boiling regime and exploring the potential benefits of the use of nanofluids. The team at IST-ID also supported the numerical model of the heat pipe, developed by the team at FEUP. Portuguese teams explored working conditions relevant for applications in electric cars (electronics cooling and batteries cooling).

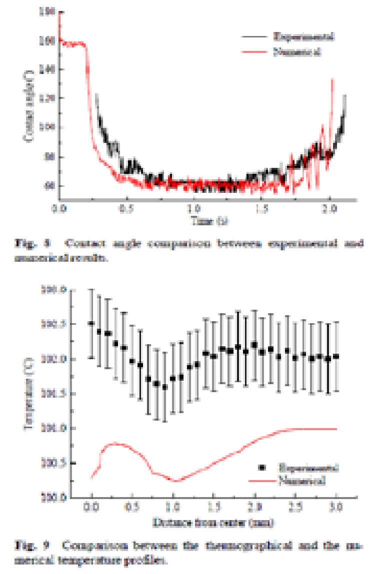




Implementation Challenges

The experimental implementation brought some challenges, particularly in the exploratory task regarding the evaluation of the potential enhancement introduced by using nanofluids. Also, from the experimental point of view, setting the entire heat pipe also turn to be extensively demanding, so that both teams in PT and in the USA decided to focus on the evaporator, as this is a major component assuring the good performance of the heat pipe. From the numerical point of view, the accurate modelling of the electrostatic application also turned out to be a challenge but it was overcome based on the extensive experience of the workgroups in Portugal, and making the most out of other collaborations (outside the project) for instance with the University of Brighton, who allowed us to understand our main problems and overcome the difficulties.





Main Findings

The project mainly showed that evaporation characteristics can be increased by further enhancing wetting properties of the evaporator surface (working as the dissipator). The model further provided interesting features on the boiling regime and on the mechanisms explaining such heat transfer enhancement. The results also show that the use of nanofluids offers a potential increase to the boiling heat transfer. However, stability issues limit the concentration of the nanoparticles to be used, thus limiting the enhancement effects. On the other hand, the team at IN+/IST-ID could develop (in collaboration with FEUP) and characterize new sets of stable nanofluids, with potential use in the heat transfer enhancement for several cooling applications. Finally, from the practical side, model and experiments suggest that this heat pipe configuration can be used for cooling purposes in the electric motorizations and in the batteries.

Expected Impact

This work will enable future development of a new class of heat pipes with much higher performance than current heat pipes, with a very low power consumption. This can favourably impact the energy efficiency in many thermal systems.
One of the major goals of Electrowave was to evaluate how this disruptive technology could be used in the thermal management of electric vehicles. In fact, efficient thermal management in these vehicles, particularly considering batteries is a real obstacle towards their broader implementation in the mass mobility market, given the current limitations in fast charging.
Electrowave showed that such EHP technology is able to cope with the specific thermal management requirements of this important market.

Project Highlights

- Project of new EHP was based on an original patent.
- New nanofluids were prepared and characterized in this new project.
- These new nanofluids can be applied in a much broader range of applications, opening a new market opportunity.
- Work presented at the 16th UK Heat Transfer Conference was selected as a highlight and invited to a full publication (in JBE).
- Project results brought up the attention to be presented in the Portuguese media.

TEAM

PI in Portugal:
Ana Sofia Moita, Association of Instituto Superior Técnico for Research and Development (IST-ID)

PI at UT Austin:
Vaibhav Bahadur, Walker Department of Mechanical Engineering, Cockrell School of Engineering

Other partnering organizations:
Faculty of Engineering of the University of Porto

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