ADENEAS Newsletter 6

Cooling technology using nano-materials

Hello there!

We're thrilled to introduce ourselves as Ir. Sana Fateh (CEO) and Dr. Alexander Korobko (CTO), two passionate researchers from Synano. Sana is an expert in thermal management systems, while Alexander brings a wealth of knowledge in physics and chemistry. Together, we work on developing cutting-edge cooling technology using nano-materials. At Synano, our mission is to enhance the performance of high-power electronics by improving their heat transfer capabilities. We achieve this by conducting extensive research and experimenting with nanofluids and nanoparticle coatings. The result is faster, lighter, and more energy-efficient electronics. We're excited to be part of a groundbreaking field that has the potential to revolutionize multiple industries.

We're excited to share with you the latest updates on our work with ADENEAS. The overall goal is to pave the way for the design and development of a cutting-edge power and data distribution network that's safe, light, self-configuring, autonomous, and modular, scalable to all aircraft sizes. Synano is playing a crucial role in this project by investigating how nanofluids and nanoparticle depositions can enhance energy efficiency in single and two-phase cooling systems, as part of WP-5. Our goal is to reduce the weight and improve the efficiency of cooling systems in electric aircraft, which is a critical step towards achieving our overall mission ultimately leading to a more sustainable and eco-friendly aviation industry. We believe that this approach holds tremendous potential for revolutionizing the way we design and develop cooling systems for electric aircraft.

Nanofluids were created to improve the thermal conductivity of heat transfer media by adding nano-sized solid particles. These particles have up to three times higher thermal conductivity than traditional fluids. Over the last two decades, nanofluids have been shown to be better at removing heat than conventional fluids. They exhibit enhanced thermo-physical properties during single-phase flow in different convection regimes (forced, natural, and mixed convection). In two-phase

systems, nanofluids improve heat transfer during boiling through two mechanisms: nanoparticle interactions with bubbles and the deposition of highly conductive nanoparticles forming a porous layer on the heater surface, which improves thermal conductivity.

For the ADENEAS WP-5 deliverables, a comprehensive investigation was conducted to address various research questions related to boiling heat transfer using nanofluids, including the physical mechanisms and relevant parameters governing the process, the potential improvement in thermal performance with nanoparticles, as well as the important considerations in synthesizing nanofluids or developing nanoparticle coatings. In addition, the study aimed to determine whether nanofluids are more effective as boiling heat transfer media compared to nanoparticle coatings on the surface, and whether the results obtained are repeatable and reproducible.

To address these research questions, Synano designed, developed, and constructed laboratory-level pool boiling and single-phase cooling setups. These setups were used to conduct experiments where nanofluids and nanoparticle coatings were tested and compared against base fluids (i.e., fluids without nanoparticles). The objective was to evaluate the performance of these materials in terms of their boiling heat transfer characteristics and thermal efficiency.

The experiments were conducted using Alumina nanoparticles with an average diameter of 100nm. To synthesize the nanofluids for the single-phase cooling system, a mixture of water and ethylene glycol in a 50:50 volume ratio was used with varying concentrations of alumina nanoparticles. In the case of pool boiling experiment, an alumina nanofluid with a nanoparticle concentration of 0.1% by weight, and demi-water as base fluid was utilized. To create nano-coatings on the sample surfaces for pool boiling and the interior of the sample pipe for the single-phase cooling system, water and acetone based alumina nanofluids were employed. To ensure the reliability and validity of the data collected, all experiments were repeated multiple times for each sample. This was done to obtain repeatable and reproducible results that could be analyzed and compared in a consistent manner.

The experimental results indicated that the application of nanoparticle coatings yielded better outcomes in both single-phase and pool boiling systems, as compared to nanofluids. In the case of the single-phase system, it was observed that the application of nanoparticle coatings resulted in a 3 degC reduction in surface temperatures of the heater at the same power of 125W, as compared to the original non-modified surface. Similarly, in the pool boiling experiments, it was observed that the maximum superheat temperature reduction of 9 degC was achieved for the nanoparticle-coated surface as compared to the non-modified surface at a heat flux of 20 W/cm^2. Based on these findings, it was decided to proceed with the application of nanoparticle coatings for both single-phase and two-phase systems, which would be used for ADENEAS demonstrators.

Currently, we are dedicating our efforts to develop more robust and reliable coating methods for EPOS stator cooling plate (single phase cooling system), which will be tested by our partner, Evektor, at their laboratories. Our goal is to create a coating that can provide superior heat transfer and reduce the overall temperature of the system.

In addition to that, we are also working on designing and developing a flow boiling system to test the superheat temperature reduction with nanoparticle coatings, using R1233zd(e) as the working medium. This system represents the 2-phase MPL setup developed by NLR and will serve as the

2-phase demonstrator for ADENEAS. Our aim is to develop a reliable and efficient cooling system that can meet the high standards of the aviation industry.

At Synano, we believe in providing innovative solutions that can revolutionize the industry. We will continue to update you on our progress and share our achievements with you.

Best regards,

The Synano Team