Nanouptake: European network of nanofluid research

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Abstract: Nanouptake (Overcoming Barriers to Nanofluids Market Uptake COST Action CA15119) is a networking action built under the auspices of COST, lasting for 4 years and ending by 2020. The general idea is to bring people from different European countries together to promote the substitution of classical single-phase working fluids by two-phase suspensions consisting of a base fluid and nanometre sized particles. Thus, the main objective of Nanouptake is to create a Europe-wide network of leading R+D+i institutions, and of key industries, to develop and foster the use of nanofluids as advanced heat transfer/thermal storage materials to increase the efficiency of heat exchange and storage systems used in the industry. Nanouptake participants are grouped in four main nanofluids research topics (working groups): 1) heating, 2) cooling, 3) storage and 4) boiling, solar application, modelling and others. The last advances within these topics are discussed and evaluated within the different working groups to improve the coordinated knowledge and efforts to overcome the barriers that difficult nanofluid industrial implementation. An overview on main activities (research mobilities, meetings, conferences, etc) of Nanouptake and results (joint publications, further international research proposals and projects, reports, etc) are presented.

Introduction/Background: Nanofluids (NFs) are defined as thermal energy storage (TES) or heat transfer (HT) or fluids with enhanced heat transfer properties by the addition of nanoparticles (NPs). Despite the huge effort made in the research and development of NFs in the last decade, there are still significant barriers to their market uptake by commercial implementation in industrial applications. If these barriers are overcome, NFs will be an important player in the Value Added Materials (VAM) for the energy sector with a global-orientated market of 10 billion euros/year by 2020 and 50 billion euros/year by 2050 (for all the VAMs related to energy).

NFs are advanced materials developed by nanotechnology and fall, therefore, within one of the Key Enabling Technologies (KET) supported by the European Commission. In

addition, they are mentioned in the Strategic Energy Technology Plan (SET Plan) and the Solar Thermal Electricity Technology Roadmap as potential elements to improve the efficiency of heat exchange and thermal energy storage systems, to thus contribute to meet the European Council energy objectives for 2020.

Although some NF commercial applications currently exist, most of NFs are at Technological Readiness Levels (TRL) 1 to 3. Most NF research has been conducted by research, development and innovation (R+D+i) centres through national funding without coordination. Additional coordinated research and development efforts are required to develop NFs up to higher TRL levels and to overcome commercial application barriers. These barriers are identified as: (1) Not coordinated European research efforts (2) NFs with enhanced thermal conductivity, but considerable pressure loss increment and stability problems (3) NFs not developed for specific industrial applications which maximize its capabilities (4) High cost and industrial manufacturing methods not developed (5) Incomplete NFs Life Cycle Assessment (LCA) issues (6) NFs research not supported by H2020 calls to develop specific NFs to higher TRL levels.

The objective of the NANOUPTAKE COST Action is to create a Europe-wide network of leading R+D+i centres, and of key industries, to develop and foster the use of NFs as advanced heat transfer/thermal storage materials to increase the efficiency of heat exchange and storage systems. For further details see also https://www.cost.eu/actions/CA15119/

Discussion and Results: Nanouptake is a COST Action financed by COST Association (www.cost.eu) . It started in May 2016 and will last for four years. The network of participant countries keeps growing, as during the duration of the Action, new members can enter the network: At the moment there are 25 participants countries involved (out the 38 possible members), includes 260 participants in the field of nanofluids, both from R+D+i centers and industries.

The work of NANOUPTAKE is organised in five working groups.

- WG#1 Heating systems operated with nanofluids
- WG#2 Cooling (including refrigeration) systems operated with nanofluids
- WG#3 Storage of thermal energy employing nanoparticle enhanced systems
- WG#4 Phase change of two-phase systems (solid/liquid) and solar application
- WG#5 Dissemination, publications and press work

The main activities developed within the COST Action are the following:

- Working group meetings. Including management meeting, dissemination meetings, or research meetings as congresses

· Short Term Scientific Missions (STSM), which are institutional visits aimed at supporting individual mobility, fostering collaboration between individuals.

· Training Schools, which provide intensive training in emerging research topics within the laboratories and organisations involved in the Action

· ITC Conference Grants are aimed at supporting early career investigators and PhD students from Participating ITC (Inclusiveness Target Countries, in blue in Figure 2) to attend international science and technology related conferences on the topic of the Action that are not organised by the COST Action

Many results have been obtained during the development of the Nanouptake COST Action, which are aligned with the initially defined objetives of the project. To have a better view of the results, some of the numbers of the Action are:

- 25 COST countries, 11 Inclusiveness Target Countries (ITC) and 1 International Partner Countriy are part of the Nanouptake network
- There are 260 Nanouptake participants, representing universities, research institutes and enterprises
- Four Working Group Meeting have been organized so far within the network, which a total attendance of 287 participants
- There have been 49 Short Termn Scientific Missions (STSM) involving 14 different countries
- A total of 108 people were involved in the three Training Schools performed so far
- Up to 13 young participants from ITC countries of the network had the possibility to present their research results in international conferences thanks to the grants of the action

Additionally, the dissemination to society is of a high importance for Nanouptake, that is why there is a special attention among the network regarding this issue. Many results from the network are included in its website (www.nanouptake.eu), and in addition to that:

- More than 40 digital news about Nanouptake have been released in the media
- Nanouptake has been presented in more than 9 dissemination events in congresses and meetings
- Nanouptake is present in different social networks (facebook, twitter, linkedin), where members of the action share the different activities in which they participate
- Nanouptake network also has a research profile in Researchgate, with more than 150 participants that share their nanofluids papers and joint contributions, so that the people can be updated with the latest advances in the field.

However, the most important objective of the action is that all this activities produce fruitful collaborations that promote a step forward in the research field of nanofluids. This has been the case, as during only the first two years of action all this collateral research advances have been obtained:

- A total of 46 joint publications among Nanouptake members have been obtained (1 book, 1 book of abtracts, 21 published articles, 8 under revision and 15 conference/congress papers)
- Up to 9 joint research proposals have been already submitted to international funding among Nanouptake members and 4 for of them for H2020

Still there are several challenges to be covered in the second half of Nanouptake, but the already developed collaborations within the network will facilitate the task.

Summary/Conclusions: Nanouptake networks has proved effective in promoting the research in the different energy fields of nanofluids. Many collaborations among the participants in the network have derived in joint research publications and projects. For sure the new activity of 1st International Conference on Nanofluids (ICNf2019) will also be a step further in the advances in this field.

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