Cast Cellular Structures to Improve Heat Transfer in TES Systems

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ABSTRACT

Phase change materials (PCMs) are commonly applied in thermal energy storage (TES) units. They offer an outstanding possibility of temporary accumulation of energy delivered to the system (from waste or renewable sources e.g. solar) in the form of latent heat of fusion, which is further recovered during solidification stage and can be used to facilitate various technological processes. Among widely utilized phase change materials different salts and their mixtures or solutions can be distinguished such as hydrates or eutectic composition of nitrates. Their main drawback is that they exhibit low thermal conductivity what drastically prolongs their heating period up to the full melting, making them unsuitable to be charged directly from solar thermal collectors at some latitudes. One way to mitigate this inconvenience is to immerse thin-walled metallic structures within PCM deposits to increase the effective heat transfer rate. Such thermal enhancers can be fabricated by a combination of two novel technologies: 3D printing (fused deposition modelling, FDM) and subsequent investment casting. For this purpose cellular honeycomb-type structures can be designed and cast from selected aluminum alloys (e.g. EN AC-44200). Presence of these lightweight castings in LTES units can not only speed up the charging process but also help to homogenize the overall temperature distribution. Another key aspect of this solution is related to the corrosion risk of metal parts in harsh environment of molten salts, especially in relation to salt hydrates (e.g. magnesium chloride salt hydrate $MgCl2 \cdot H2O$). A protective measure may be to deposit anti-corrosive coatings done by plasma electrolytic oxidation (PEO) method on the surface of cast aluminum inserts.

Keywords: Latent Thermal Energy Storage; Cellular Structure; Heat Transfer Enhancer; PEO coating.

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Biography: PhD Eng. Anna Dmitruk is employed as an assistant professor at the Department of Lightweight Elements Engineering, Foundry, and Automation of the Faculty of Mechanical Engineering of Wroclaw University of Science and Technology, where from 2020 sheisalso the Deputy Head of the Department. Her research interests include the production and application of materials used in thermal energy storage, composite materials, MAX phases and MXenes, light alloy casting, metallic foams, self-propagating high-temperature synthesis, and polymer processing. She is the author or co-author of several national scientific publications. In 2017, shecarried out a research internship financed by the KMM-VIN association at the Tecnalia Research and Development Center in San Sebastian, Spain. In 2018 and 2019, as part of cooperation in the CERIC-ERIC (EU) consortium, during short-term research, she conducted research at the National Institute of Materials Physics in Bucharest (Romania) and at Charles University in Prague (Czech Republic). She actively participates in national and international research projects on energy composite materials, includingg.g.: HORIZON EUROPE (EU), ERANet-LAC (EU), H2020 (EU), LIDER (NCBR, Poland), Fast Track (NCBR, Poland).