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Experimental Study on Organic PCM for High Temperature Applications

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Extended Abstract

One of the main current technological challenges is to satisfy the global growing demand for energy with a sustainable and environmentally friendly offer. For this reason, the amount of renewable energies is increasing considerably coupled to the efforts made to optimize and maximize the waste heat recovery. In fact, the waste heat released by industrial processes assures a huge potential to exploit for power generation [1]. The main issue connected to the use of these heat sources is their periodic appearance and availability and their floating characteristics. [2]

The interest in Phase Change Materials (PCMs) has been continuously growing, since they were identified as a suitable way to store large quantities of thermal energy and to couple energy production and demand.

In this work an organic PCM with a phase change temperature around 135 °C is studied. This PCM is proposed for storing heat coupled to low-medium temperature Organic Rankine Cycles, capable of recovery and reuse the waste heat or directly use renewable energies. Despite many favourable characteristics, this PCM presents a relatively low thermal conductivity, which limits the efficiency and the convenience of its use inside Latent Thermal Energy Storage (LTES) units.

This paper proposes a novel method to overcome the low thermal conductivity drawback: the additive manufacturing was used to realize some innovative 3D metallic periodic structures made of AlSi10Mg-0403 aluminum alloy, with different base pore sizes (10, 20, and 40 mm) and constant porosity, to be filled with 60 g of PCM. The samples have 42 x 42 mm^2 base area and a total height of 60 mm and they were set over a heater block made of aluminum that hosted a 200 W/240 V electric cartridge heater. The samples were experimentally tested by analyzing the temperature field during the charging (i.e. heating and melting) process, obtained by electrical heating (six heat fluxes corresponding to 30, 40, 50, 60, and 70 W were applied, heat fluxes ranging between 16 and 37 kW m^{-2}, respectively) and the discharging (i.e. solidification and cooling) process, where the heat was only rejected by natural convection with ambient still air.

Comparing the results obtained using the three 3D periodic structures and an identical sample filled only with the same amount of PCM (no 3D structure inside), it can be concluded that:

- Lower charging and discharging times were obtained when the 3D structures are used. This could guarantee faster and efficient energy storage and release.
- A more homogeneous temperature distribution in the PCM was observed when the periodic structures were tested.

For all the above-mentioned reasons, this innovative technological solution should be investigated in more detail in the future, for instance by optimizing the porosity, by looking for an even smaller base size, or by taking into account different working conditions and PCMs.

References

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