Title

Thermal Energy Storage for Industrial Process Using New Copper Composite Materials

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Abstract

The storage of heat has received an increasing interest over the past years in different applications such as heat waste recovery systems, thermal solar capture systems, or zero-heat houses. To capture and store heat, a heat carrier has to be included in the system. These carriers or materials must be active within a wide range of temperatures, being low to moderate in heat recovery systems, or moderate to high in mining, solar applications and heat waste recovery.

Low temperature thermal energy storage (LTTES) works in a temperature range below 200°C and has been extensively developed. LTTES applications can be found in heating and cooling building systems, air-heating systems, solar water-heating, greenhouses, etc.

High temperature thermal energy storage (HTTES), T > 200°C, has a vital role in renewable energy technologies and heat waste recovery. There is a wide range of industrial applications where heat waste can be recovered, as in the mining and metallurgical industry, manufacturing of construction materials and aerospace technologies. Most HTTES usages, though, are at the time found in solar thermal plants.

The amount of heat stored by the carrier is possibly determined by 2 contributions, i.e. (i) sensible heat as a product of the carrier mass, its specific heat (C_p) and the prevailing temperature difference (ΔT) , and/or (ii) latent heat of phase transitions that can occur in some of the selected heat carriers. Within low to moderate ranges of temperatures, the sensible heat contribution within the recovery is of limited impact due to the low values of the specific heat, the limited ranges of useable temperature differences and the limitations on amount (mass) of carrier present (weight + cost). If a substantial amount of heat needs to be captured, stored, and released for further applications, the application of phase transitions and associated latent heat becomes essential, always nearly an order of magnitude in excess of $Cp \cdot \Delta T$, thus allowing to reduce the amount of carrier needed by the same ratio.

Within these fundamentals, recent research focuses upon the development of appropriate Phase Change Materials (PCM), in function of the ranges of applied temperatures. The selection of a PCM is moreover determined by its heat storage efficiency, its thermodynamic properties, and its mechanical properties within the intended option of temperature variations (capture vs. release, material thermal expansion, loss of mechanical properties upon heating,…).The purpose of this work is: first, to show the thermo-hydro-mechanical properties and behaviour of copper porous foam, as porous media with high conductivity and elasticity, and Phase Change Material (PCMs) in order to explain their behaviour; second, given the analysis, to improve of the heat transfer process and therefore the charging and discharging efficiency. Is necessary, storing the wasted energy of some industrial processes to be recycled and applied to another processes. Achieving this way on the wasted energy recovery and producing an improvement in the mining industry`s energy efficiency.

To boost the future of PCM applications, it is hence important to investigate the fundamental properties, and their variation during the application (temperature cycling from capture to release, mechanical stress and/or erosion during the physical PCM circulation between heat source and release recipient, internal pressure build-up during the phase change, etc.).

The proposed work tries to solve these expected problems by studying the following objectives:

1) Characterization and selection of the high-quality PCM/copper composite through his thermo-physical properties.
2) Market study: copper foam and PCM selection (mainly salts) regarding availability to exploitation (natural resources), scope of sale price variation, capacity and volume of production (manufacturing process), value added in production with certain physical properties imposed.
3) Determination and development of adequate microstructural characterization of *copper foams* imbibed with salt or other PCM, in order to have a proper definition of the structural parameters that influence heat transfer dynamics.

The results are moreover consequence of formulation heat transfer enhancement strategies, with high efficiency, and commercial potential. It will moreover define the optimum balance between energy supply and demand within systems of renewable energy or heat waste recovery.

We want to contribute to a better, enhanced knowledge of heat transfer in copper foams integrated to PCMs, advance the development of thermal storage media and build the foundation to the design of reliable thermal storage systems apt to commercial use in industrial processes.