World Academy of Science, Engineering and Technology
International Journal of Mechanical and Industrial Engineering
Vol:13, No:06, 2019

Numerical Investigation of Solid Subcooling on a Low Melting Point Metal in Latent Thermal Energy Storage Systems Based on Flat Slab Configuration

Authors : Cleyton S. Stampa

Abstract : This paper addresses the perspectives of using low melting point metals (LMPMs) as phase change materials (PCMs) in latent thermal energy storage (LTES) units, through a numerical approach. This is a new class of PCMs that has been one of the most prospective alternatives to be considered in LTES, due to these materials present high thermal conductivity and elevated heat of fusion, per unit volume. The chosen type of LTES consists of several horizontal parallel slabs filled with PCM. The heat transfer fluid (HTF) circulates through the channel formed between each two consecutive slabs on a laminar regime through forced convection. The study deals with the LTES charging process (heat-storing) by using pure gallium as PCM, and it considers heat conduction in the solid phase during melting driven by natural convection in the melt. The transient heat transfer problem is analyzed in one arbitrary slab under the influence of the HTF. The mathematical model to simulate the isothermal phase change is based on a volume-averaged enthalpy method, which is successfully verified by comparing its predictions with experimental data from works available in the pertinent literature. Regarding the convective heat transfer problem in the HTF, it is assumed that the flow is thermally developing, whereas the velocity profile is already fully developed. The study aims to learn about the effect of the solid subcooling in the melting rate through comparisons with the melting process of the solid in which it starts to melt from its fusion temperature. In order to best understand this effect in a metallic compound, as it is the case of pure gallium, the study also evaluates under the same conditions established for the gallium, the melting process of commercial paraffin wax (organic compound) and of the calcium chloride hexahydrate ($CaCl_2$ $6H_2O$-inorganic compound). In the present work, it is adopted the best options that have been established by several researchers in their parametric studies with respect to this type of LTES, which lead to high values of thermal efficiency. To do so, concerning with the geometric aspects, one considers a gap of the channel formed by two consecutive slabs, thickness and length of the slab. About the HTF, one considers the type of fluid, the mass flow rate, and inlet temperature.

Keywords : flat slab, heat storing, pure metal, solid subcooling
Conference Title : ICME 2019 : International Conference on Mechanical Engineering
Conference Location : Paris, France
Conference Dates : June 25-26, 2019