World Academy of Science, Engineering and Technology
International Journal of Mechanical and Industrial Engineering
Vol:14, No:08, 2020

Thermal Regulation of Channel Flows Using Phase Change Material

Authors : Kira Toxopeus, Kamran Siddiqui

Abstract : Channel flows are common in a wide range of engineering applications. In some types of channel flows, particularly the ones involving chemical or biological processes, the control of the flow temperature is crucial to maintain the optimal conditions for the chemical reaction or to control the growth of biological species. This often becomes an issue when the flow experiences temperature fluctuations due to external conditions. While active heating and cooling could regulate the channel temperature, it may not be feasible logistically or economically and is also regarded as a non-sustainable option. Thermal energy storage utilizing phase change material (PCM) could provide the required thermal regulation sustainably by storing the excess heat from the channel and releasing it back as required, thus regulating the channel temperature within a range in the proximity of the PCM melting temperature. However, in designing such systems, the configuration of the PCM storage within the channel is critical as it could influence the channel flow dynamics, which would, in turn, affect the heat exchange between the channel fluid and the PCM. The present research is focused on the investigation of the flow dynamical behavior in the channel during heat transfer from the channel flow to the PCM thermal energy storage. Offset vertical columns in a narrow channel were used that contained the PCM. Two different column shapes, square and circular, were considered. Water was used as the channel fluid that entered the channel at a temperature higher than that of the PCM melting temperature. Hence, as the water was passing through the channel, the heat was being transferred from the water to the PCM, causing the PCM to store the heat through a phase transition from solid to liquid. Particle image velocimetry (PIV) was used to measure the two-dimensional velocity field of the channel flow as it flows between the PCM columns. Thermocouples were also attached to the PCM columns to measure the PCM temperature at three different heights. Three different water flow rates (0.5, 0.75 and 1.2 liters/min) were considered. At each flow rate, experiments were conducted at three different inlet water temperatures (28^{o}C, 33^{o}C and 38^{o}C). The results show that the flow rate and the inlet temperature influenced the flow behavior inside the channel.

Keywords : channel flow, phase change material, thermal energy storage, thermal regulation
Conference Title : ICTESETA 2020 : International Conference on Thermal Energy Storage, Engineering, Technology and Applications
Conference Location : Paris, France
Conference Dates : August 27-28, 2020