Numerical Investigation of Thermal Energy Storage Panel Using Nanoparticle Enhanced Phase Change Material for Micro-Satellites

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Abstract : In space, electronic devices are constantly attacked with radiation, which causes certain parts to fail or behave in unpredictable ways. To advance the thermal controllability for microsatellites, we need a new approach and thermal control system that is smaller than that on conventional satellites and that demand no electric power. Heat exchange inside the microsatellites is not that easy as conventional satellites due to the smaller size. With slight mass gain and no electric power, accommodating heat using phase change materials (PCMs) is a strong candidate for solving micro satellites' thermal difficulty. In other words, PCMs can absorb or produce heat in the form of latent heat, changing their phase and minimalizing the temperature fluctuation around the phase change point. The main restriction for these systems is thermal conductivity weakness of common PCMs. As PCM is having low thermal conductivity, it increases the melting and solidification time, which is not suitable for specific application like electronic cooling. In order to increase the thermal conductivity nanoparticles are introduced. Adding the nanoparticles in base PCM increases the thermal conductivity. Increase in weight concentration increases the thermal conductivity. This paper numerically investigates the thermal energy storage panel with nanoparticle enhanced phase change material. Silver nanostructure have increased the thermal properties of the base PCM, eicosane. Different weight concentration (1, 2, 3.5, 5, 6.5, 8, 10%) of silver enhanced phase change material was considered. Both steady state and transient analysis was performed to compare the characteristics of nanoparticle enhanced phase material at different heat loads. Results showed that in steady state, the temperature near the front panel reduced and temperature on NePCM panel increased as the weight concentration increased. With the increase in thermal conductivity more heat was absorbed into the NePCM panel. In transient analysis, it was found that the effect of nanoparticle concentration on maximum temperature of the system was reduced as the melting point of the material reduced with increase in weight concentration. But for the heat load of maximum 20W, the model with NePCM did not attain the melting point temperature. Therefore it showed that the model with NePCM is capable of holding more heat load. In order to study the heat load capacity double the load is given, maximum of 40W was given as first half of the cycle and the other is given constant OW. Higher temperature was obtained comparing the other heat load. The panel maintained a constant temperature for a long duration according to the NePCM melting point. In both the analysis, the uniformity of temperature of the TESP was shown. Using Ag-NePCM it allows maintaining a constant peak temperature near the melting point. Therefore, by altering the weight concentration of the Ag-NePCM it is possible to create an optimum operating temperature required for the effective working of the electronics components.

Keywords : carbon-fiber-reinforced polymer, micro/nano-satellite, nanoparticle phase change material, thermal energy storage
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