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PERFORMANCE ANALYSIS OF A VAPOR COMPRESSION HEAT PUMP SYSTEM FOR SOLAR POWER SATELLITES

Abstract

A solar power satellite (SPS) has been received much attention in recent years because it is a potential clean energy source to solve the global resources and environmental problems. For a typical design of a SPS which can deliver several GWe to the Earth's surface, one of the key issues is to dissipate several megawatt waste heat to the space. Accordingly, an efficient and lightweight heat rejection subsystem is required. Closed systems for waste heat rejection in space are radiative and their capacity is proportional to the fourth power of absolute temperature. Reductions in the surface area and therefore, in the mass of a space radiator are possible by increasing the heat rejection temperature above the temperature of the thermal source. In this paper, a concept based on vapor compression heat pump augmented space radiator heat rejection was presented. An optimization study was performed to quantify the effects of several sensitive parameters such as coefficient of performance (COP) of vapor compression heat pump system, operating temperature and specific-mass of radiator, mass penalties associated with its power supply and its heat rejection system, and acquisition temperature of evaporator on total mass of heat pump system. The optimal rejection temperature and optimal mass of the heat pump system were calculated under various parameters. The use of a heat pump augmented heat rejection system will generally be practical if it reduces the total mass requirement over a suitable baseline design. The analytical results show that the heat pump system can enhance heat rejection of space radiator and reduce the total mass of thermal control system of SPS, also show its promising prospects in future aerospace applications.