THERMAL STORAGE FOR SOLAR DYNAMIC POWER GENERATION: PERFORMANCE INDICATORS IN A SECOND LAW PERSPECTIVE

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Thermal storage in a solid-liquid phase change in conjunction with solar dynamic power generation is a matter of growing interest due to the space applications perspectives. Second law analyses have been conducted to determine the optimum design and operation of a Latent Heat Thermal Storage Module (TSM) in which the heat charge and retrieval is both performed by flowing streams of fluids. Generally these studies consider the charge phase alone, and assume that the exergy of the hot fluid stream during the active phase is discharged into the ambient and completely destroyed, unless it is partially intercepted by the TSM. In a recent paper De Lucia and Bejan (1991) extended their analysis to the effect of superheating in the liquid phase and considered an entire cycle of the process, taking into account the retrieval stroke too. They found that the optimum melting temperature of the Phase Change Material (PCM) is slightly greater than but not too far from the geometric average of the heat source temperature and the environment temperature. The basic concept that underlies these studies is that minimum entropy production leads to an optimum design and operation of the storage element. However, these studies are based on a particular configuration of the conversion system; moreover they fail to account adequately for the cyclic behaviour of the storage and removal processes.

In this paper the performances of a TSM are numerically investigated. Entropy sources and fluxes are analysed to evaluate the second-law efficiency of the system. Key differences between our approach and the one by De Lucia and Bejan are:

i) Attention is focused on the steady cyclic behaviour of the system, when cyclic reproducibility of the interesting parameters is attained.

ii) During the charge phase heat is stored by partially cooling the hot fluid stream in the TSM. The fluid stream emerging from the storage module is then supplied to the heat engine.

The latter condition implies the connection of the storage module in series between the solar collector and the heat engine. Therefore thermal storage is attained at the expense of the available temperature level. A conceptually similar scheme is the basic layout of conversion systems designed for both terrestrial and space applications.

A proper design of the storage module should ensure a continuous operation of the conversion system as well as economy in the storage mass. The results of the present study show that minimum entropy production cannot be considered a satisfactory approach in this respect. A different figure of merit is suggested, and guidelines are provided for the optimization of the storage system.

Reference

M. De Lucia and A. Bejan, "Thermodynamics of phase-change energy storage: the effects of liquid superheating during melting and irreversibility during solidification". *J. Sol. Energy Eng.* **113**, 2-10 (1991)