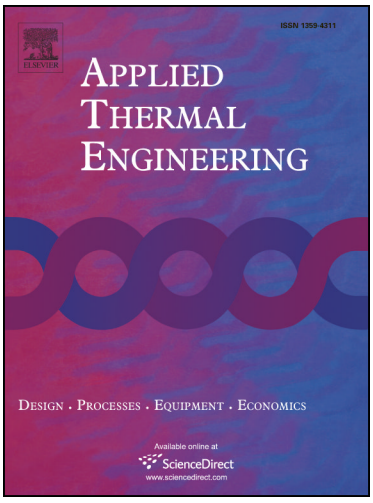

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An experimental and computational approach to thermoelectric-based conditioned mattresses

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Abstract

This paper sets out to describe the design, construction and testing of a thermoelectric-based conditioned mattress intended to reduce the human-mattress interface temperature, in order to increase the user's sleep quality and thermal comfort in warm locations of Spain. A prototype is constructed and tested, which includes a mattress and a thermoelectric system that cools the inner air and governs the human-mattress interface temperature. This temperature results 2.1 ºC lower than that of the room ambient, for 90 W of supplied electric power to the thermoelectric modules, with a coefficient of performance of 0.34. Under this scenario, the comfort perceived by the user is expected to improve compared to that provided by a no-conditioned mattress. The prototype is modified so that the inner air is pumped directly to the human body. With this improvement, the relevant temperature is now that of the inner air, which results 3.4 ºC lower than the room ambient temperature, thus expected to increase even more the comfort perceived by the user, with 0.58 of coefficient of performance. In order to simulate both the transient and steady state of the global system, a lumped-capacitance model is devised specifically for this application. The validation process is conducted comparing simulated and experimental values of electric current, temperature difference between ends of the modules, temperature difference between the inner air and the ambient, and coefficient of performance. In steady state, the theoretical model predicts the experimental results with deviations below ±9 %. Computational results indicate that the inner air temperature increases by only 1 ºC, when air humidity increases from zero to 100 %. Under the 100%-humidity scenario, the inner air temperature is still 2.4 ºC lower than the room ambient temperature, reducing slightly the coefficient of performance to 0.47.

Keywords: sleep comfort; air conditioned mattress; Peltier effect; dynamic simulation; experimental testing; relative humidity