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Summer Energy Saving In Indoor Environments Using A New Free-Cooling System

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Extended Abstract.

Indoor cooling systems with low energy requirements might yield significant energy saving in warm and mild summer climates. In this regard, cooling by means of water evaporation is of particular interest since energy consumption is limited to the fan load. The cooling system proposed in this paper combines a radiant ceiling panel with a new indirect evaporative process carried out by means of a membrane contactor (MC) equipped with a hydrophobic membrane that is permeable to vapour but not to the liquid phase. In comparison with a direct-contact air-water evaporative process, the MC allows the frontal velocity of the air to be varied with a flexibility of up to 4-5 m/s, while avoiding the carryover of water droplets, facilitating compactness and achieving high cooling efficiency. The system studied combines two subsystems: a radiant ceiling panel (RCP) fed by chilled water, and the MC with the heat exchanger (HE) (Fig. 1).

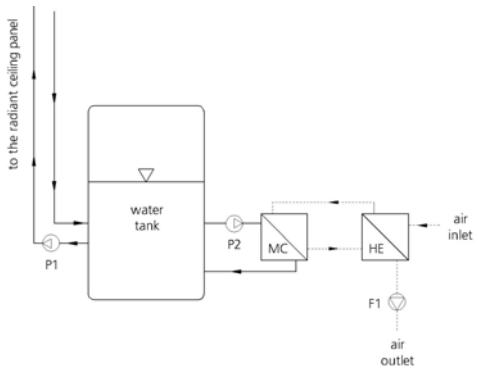

FIG. 1. The indirect evaporative cooling system; MC coupled to HE on the air path

The system was studied by means of a SIMULINK_ MATLAB code particularly suited to simulate the dynamic behaviour of complex systems by reducing their components to graphical interfaces. The present theoretical analysis was carried out by comparing the heat pump energy consumptions required to maintain the predicted mean vote index (PMV) at a level not exceeding + 0.5 for a room with or without the cooling system.
From the results obtained, the following conclusions can be drawn:

- the optimum ratio between the flow rates of water and air conveyed to MC is close to 0.3;
- the heat loads removed by the cooling system increases significantly as the relative humidity the outdoor air decreases;
- in summer conditions, the cooling system enables both the mean radiant temperature and the indoor air temperature of the room to be reduced, thereby lowering the energy requirements of the heat pump;
- without the heat pump, PMV reaches values of 1.2 -1.5 for a limited time (5-6 hours), despite the cooling system; without any control, PMV values becomes totally unacceptable (PMV > +3);
- in the climatic conditions considered, the electrical energy saved by the heat pump is in the range 32%÷ 43%, while maintaining indoor comfort;
- if the heat exchanger is excluded and a lower air flow rate is set, the pressure losses along the air path reduce, the cooling system operates at a lower efficiency, but as a result, the electrical energy saving rises from 43% to 59%.