Karlsruher Institut für Technologie

Heat | Hydrogen | Resilience

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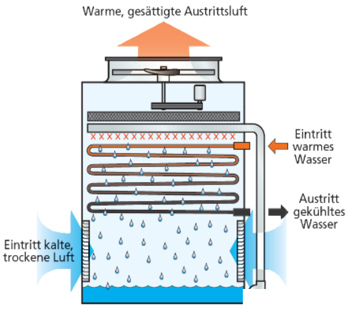
Master Thesis

Comparison of two models for calculating closed evaporative coolers

Closed evaporative coolers are process engineering devices that extract heat from a medium by evaporating water into a stream of air. The medium cools down or condenses as a result. The coolers are often the heat sink of a refrigeration machine.
For this purpose, water is pumped from a basin to a distribution device (secondary circuit) and trickled through a pipe bundle. The water film flows downwards and drips back into the basin. A valve gate conveys ambient air in counterflow via the tube bundle. Water evaporates into the air and the film cools down on its surface and thus extracts heat from the medium in the coil (primary circuit).



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With this arrangement, temperatures below the ambient air temperature can be achieved up to close to the wet bulb temperature. Dry operation (without secondary circuit) is also possible in cold weather. Finally, the process can be reversed and the device can be used (especially) in winter as an evaporator or heat source for a heat pump.
There are two main approaches to calculation in the literature.
Approach 1 assumes that the temperature of the water film changes locally does not change (infinite capacity) and leads to an equation for determining the outlet temperature of the cooled medium which must be solved numerically by iteration. This leads to deviations from the real behavior, especially with larger differences between inlet and outlet temperature (see Kröger).

Approach 2 divides the apparatus two-dimensionally into cells. This results in a system of equations which, due to the feedback caused by the circulating water flow, must also be solved numerically in an iterative manner (see W.-Y. Zheng et al.).
The task is to map the models in a software (Excel VBA, Matlab, ...) and to determine and discuss the limits of the first approach by means of quasi-stationary simulation calculations.
The results should also be used to dimension an experiment on the basis of which the models can be validated in subsequent work.

Kröger, Detlev G., Air-cooled heat exchangers and cooling towers, 2004, PennWell Corporation
W.-Y. Zheng et al., Thermal performance analysis of closed wet cooling towers under both unsaturated and supersaturated conditions; International Journal of Heat and Mass Transfer 55 (2012) 7803–7811

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