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Cooling tower performance in closed loop systems

The capacity/performance of a cooling tower is determined by following parameters:
T in = water inlet temperature ℃
T out = water outlet temperature ℃
T WB = wet-bulb temperature at the air inlet of the tower ℃
Flow = water flow in l/s through the tower
(The airflow or fan speed through the tower is also important but in this paper we consider the airflow to be constant).

So in short a cooling tower design capacity will or can be noted as :
T in / T out / T WB / flow egg. 35/30/20℃ 20 l/s

From above values, following factors can be calculated:

a) Range (℃) = Tin – T out
Also often referred to as ΔT
b) Approach (℃) = T out – T WB
c) Heat load (kW) = Range (℃) x flow (l/s) x speci fic heat (kJ/kg℃) x density (kg/l)

We assume a pump with fixed speed on a cooling,so we consider the water flow to be constant. We assume the flow over the cooling tower is equal to the flow over the heat source. In that case we can see from above formula that the Range and Heat load are proportional. This means that if the Range changes by x %, the heat load also changes by x %.

If we consider a situation during which the T WB remains stable or constant then following is true:

The larger the heat load (Range) is put on a tower, the larger the approach becomes to evacuate this load.
The smaller the heat load (Range) presented to the tower, the smaller the approach will become. In fact, if no load is presented to the tower (ΔT or range = 0), the approach becomes zero. In that case T in = T out = T WB

Increasing the load on the tower will make all 3 temperatures move further away from each other.
Please note that the cooling tower does not determine the Range, but it does determine the approach.
The smaller the load put on the tower, the smaller the approach. If a fixed load is put on different sizes of cooling towers, we will see that the bigger the tower is, the smaller the approach becomes. The range (ΔT) in both cases remains however the same (considering the same flow rate and heat load on both towers).

Conclusion:

- To check if a cooling tower is performing as it should be, one should check if the approach measured on the tower corresponds with the expected approach (related to the load put on it)
- In other words: theoretically a cooling tower can reject any heat load presented to it, but not at the same approach.
    - o a smaller tower (or bad designed or polluted tower) will require a big approach
    - o a big tower will have a small approach

  The ΔT is not determined by the tower, but by the presented cooling load.
- The cooling tower will adapt the approach until it is able to meet exactly the presented cooling load. If the load is increased the approach will increase and vice versa.
- Please note that the approach is in function of the wet-bulb temperature. At lower wet-bulb temperatures, larger approaches are needed to reject the same cooling load as on higher WB temperatures.

  The heat load (and the water flow) determines the ΔT (Range). The size of the tower and the airflow through it determine how high the temperature will be above the wet-bulb temperature (approach).

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