

CHME 401 CHEMICAL ENGINEERING LABORATORY II
EXPERIMENT 401-3
COOLING TOWER

OBJECTIVE

The objective of the experiment is to make material and energy balances over cooling tower apparatus and to determine performance of cooling tower at different operating conditions.

PRELIMINARY WORK

1. Study the basic principles of psychrometry and cooling tower applications.
2. Visit the lab in advance to experiment and familiarize yourself with the experimental set-up with the consent of the teaching assistant.

DESCRIPTION OF THE EXPERIMENTAL SET-UP

The apparatus consists of a rectangular transparent tower with three different packing in addition a hot water reservoir, pump and a centrifugal fan.

Cold water trickles down over the packing material as it cools down by a forced draught of air supplied at the base of the tower by the fan. The water cooled down recollected in hot water reservoir and the amount of water is kept constant by addition of water from a make-up water reservoir.

Air flow rate can be controlled by use of a damper and be measured by an orifice plate and noted as pressure difference while water flow rate is measured by using a rotameter and controlled by use of valves.

Air inlet and outlet temperatures (both dry and wet), water inlet and outlet temperatures and temperatures of make-up water reservoir and hot water reservoir is measured by use of digital thermometers. Cooling tower apparatus is shown in Figure 1.



Figure 1. Cooling Tower Apparatus

EXPERIMENTATION

During the experiments, all temperature values, gas and liquid flow rates must be recorded.

Procedure

- 1) Fill the hot water reservoir with de-ionized water
- 2) Switch on pump (G1) by using the button on control panel to maintain water flow and set flow rate to 90 L/h
- 3) Set inlet water temperature to 20 °C from the indicator on board and switch heaters on (J1 J2 J3)
- 4) Switch on fan (P1) by using the button on control panel and set the air flow rate by using the damper behind the fan to a pressure difference of 16 mm H₂O (pressure drop will be read by use a of manometer on the apparatus)
- 5) Wait until steady state conditions reached
- 6) Fill the make-up water reservoir up to the mark and start taking time
- 7) After five minutes refill the reservoir to measure the amount of water evaporated during the process.
- 8) Record all temperature values and amount of water used.
- 9) Set water inlet temperatures to 30 °C and 40 °C and repeat steps 6-9

- 10) Set air flow rate by using damper to 13 and 7 mmH₂O (water inlet temperature 40 °C) and repeat steps 6-9
- 11) Turn heaters off
- 12) Wait 2-3 minutes turn fan and pump off
- 13) Replace packing material (there are two different packing except the one on the apparatus) and repeat steps 1-9. Use all packing materials indicated as A,B and C

Analysis

- 1) Make energy and material balances over the cooling tower in order to calculate the heat load of the water side and energy transfer to the air side.
- 2) In order to determine change in performance due to different operational parameter observe changes in:
 - Range : difference between inlet water temperature and outlet water temperature
 - Approach to wet bulb temperature: Difference between outlet water temperature and inlet air wet bulb temperature
 - Cooling capacity : amount of water cooled and heat load
 - Evaporative Losses: amount of water lost due to evaporation

Against inlet water temperature, air flow rate and different packing material (surface area) and show correlations graphically.

Useful Data about the apparatus

Packing Data

	A	B	C
Decks number	8	8	8
Plates number	7	10	18
Total surface m ²	1.1	1.56	2.8
Packing height m	0.53	0.53	0.53
Packing spec. Surf. Area m ² /m ³	92	131	235

Orifice Formula:

$$m = 0.0165\sqrt{(\Delta P / v_B)}$$

Where

m= dry air mass flow rate (kg/s), ΔP = orifice differential pressure (mm H₂O),

v_B = specific volume of outlet humid air (m³/kg)