

# Study the effect of different parameters on cooling range in a bench top cooling tower

Sharjeel Waqas, Muhammad Usman Tahir, Muhammad Nawaz, Naeem Akram, Shoaib Zaheer

**Abstract:** A cooling tower is a device in which combined heat and mass transfer occurs simultaneously. It is used to reduce the temperature of water by contact with ambient air. Cooling tower is the most economical and effective way of cooling and is most widely used. Natural draft and mechanical draft (forced draft and induced draft) are the types of cooling tower. Forced draft cooling tower has been used in this research to study the effect of water inlet temperature and water flow rate on cooling range in a bench top cooling tower. Water inlet temperature has been changed 30°C to 50°C and cooling range has been calculated for each value. Similarly, water flow rate has been changed from 2 to 3.5 lit/min and calculated cooling range for each value. Graph has been drawn for water inlet temperature and water flow rate vs. cooling range. Water inlet temperature and water flow rate has direct relationship with cooling range.

**Key Words:** Cooling Tower, Cooling Range, Water, Forced Draft, Vaporization, Wet Bulb Temperature

## 1 Introduction

A cooling tower is an example of device in which combined heat and mass transfer occurs to reduce water temperature by direct contact between ambient air and water through different types of packing [1]. This type of cooling tower that uses air for cooling is called wet cooling tower [2]. Cooling tower is the most widely used device as it is most effective and economical method to remove heat [3]. Cooling tower requires distribution of spraying water through the tower from which air is passed [4]. Early research on the performance of cooling tower has been conducted in 1970s. It has been used extensively in power generation units; petrochemical; chemical; refrigeration and air conditioning processes [5]. Type of packing used in a cooling tower plays an important role in increasing contact area and contact time [5]. Packing uniformly distributes the water throughout the tower and thus increases the mass transfer coefficient [2].

In order to study the effect of packing type, Kelly and Swenson [5,6] proposed a relationship for tower characteristics and water to air flow rate ratio. Dreyer and Erens [7] developed a mathematical model for evaluating thermal performance of counter flow cooling tower. A portion of the water is evaporated during the process because moisture content of the air is less than saturated air. Process of evaporation requires energy to change the water from liquid to vapor, the water is cooled [8, 9]. Different types of cooling towers are used in different processes. They can be classified as mechanical draft type and natural draft type depending on the method used to move the air [9]. Mechanical draft cooling tower can be forced draft or induced draft. Air is circulated through the tower by electrically driven fans in mechanical draft cooling tower. While natural draft cooling tower uses the buoyancy force of the hot air to cooling the incoming water. Natural draft cooling tower is used in power plants for cooling water while mechanical draft cooling towers are used in oil refineries and other similar processes. In all types of cooling tower water flows from the top the tower in downward direction while air flows in upward direction (counter flow) or horizontal direction (cross flow). During the process of cooling a portion of water is lost due to blow down, evaporation and drift. This lost water is replaced with fresh make up water [8-11]. The cooling water is then stored in a bin under the tower and then returned to the process. Moist air leaves from the top of the tower [2].

Optimization of the operating conditions for cooling tower is very important in order to make the process most energy efficient and to get the best results under these conditions. In this research work, effect of water flow rate and water inlet temperature has been studied on cooling range of the cooling tower. After finding the effect the

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optimum conditions have been found from experimental data.

## 2 Materials and Methods

A bench top cooling tower has been used in this research work. Type of cooling tower used is forced draft in which blower is installed at the bottom of the cooling tower. Ambient dry air enters from the bottom of the tower and leaves from the top as moist air. Hot water enters from the top of the column and flows in the downward direction while ambient air flows in upward direction. Counter current flow is achieved in this type of column which makes it a better heat transfer surface. Entering water from the top of the column is spread throughout the cooling tower with the help of a distributor. A distributor distributes water in the whole cooling tower and thus better contact between water and air is achieved. Packing is installed in the column to achieve maximum contact area between water and air. Bench top cooling tower is fitted with 1kW heater to heat the inlet water. Makeup water compensates the water lost during the process because some of the water content is lost with outgoing air. Water cooled in the tower is collected in a tank below tower from there it is sent to the process plant.

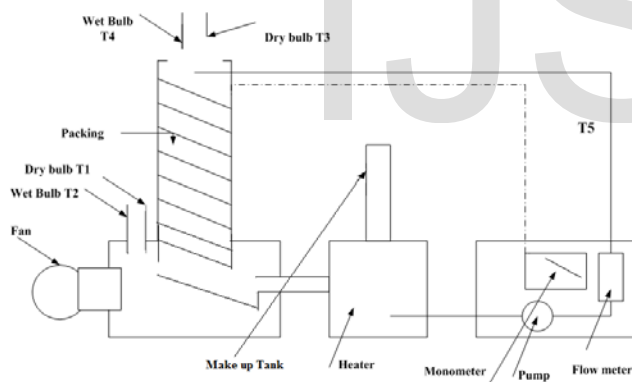
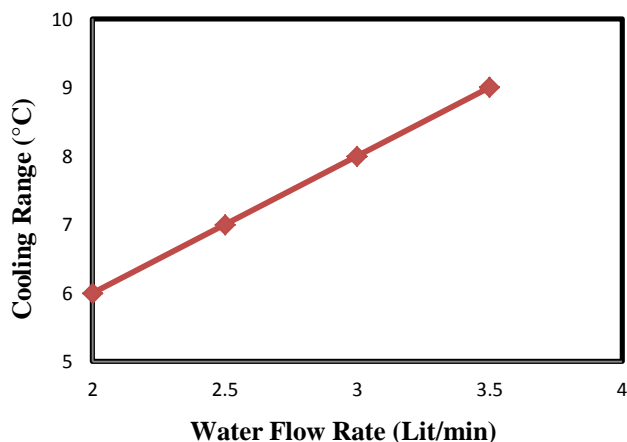


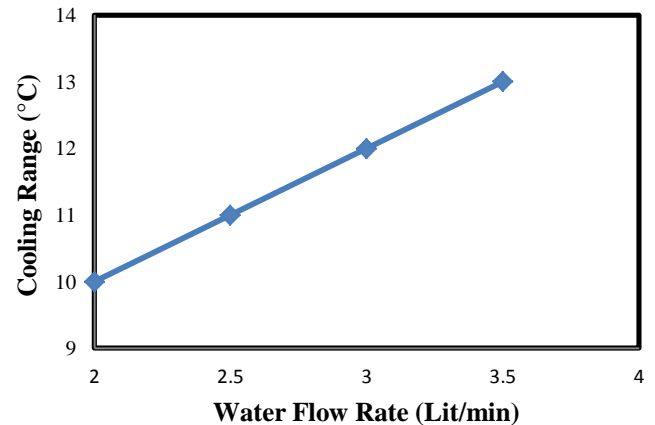
Fig. 1: Flow sheet diagram of Bench Top Cooling Tower

## 3 Results and discussion

This discussion will help to choose the best



feasible condition for cooling tower. Effect of water inlet temperature and water flow rate is discussed in this section.



### 3.1 Effect of water flow rate on cooling range

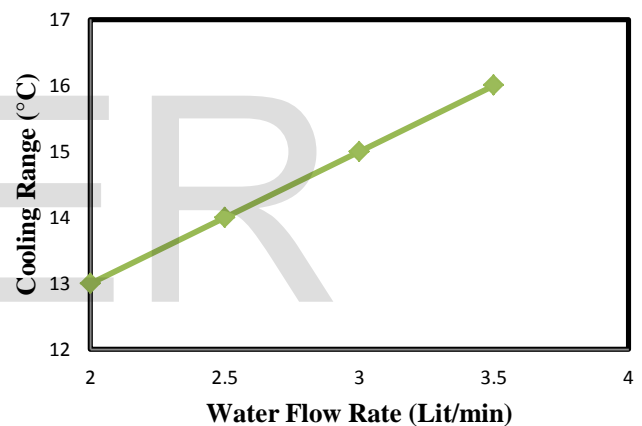


Fig. 2: Effect of water flow rate on cooling ranges at constant water inlet temperature of (a) 40°C (b) 45°C and (c) 50°C

Fig. 2(a) is the graph of flow rate of water and cooling range. Effect of water flow rate on cooling range has been calculated by keeping water inlet temperature constant. Water flow rate is on the horizontal axis while cooling range is on vertical axis. Flow rate of water has been set at 2 lit/min with constant water inlet temperature of 40°C. Water outlet temperature and ultimately cooling range has been calculated. Flow rate of water has been varied from 2 lit/min to 3.5 lit/min and cooling range has been determined for each value. Graph is the straight line for each value which means that with the increase in water flow rate, cooling range also increases.

Fig. 2(b) is the set of experiments performed to check the effect of water flow rate and cooling range at constant inlet water temperature of 45°C. Water flow rate

has been varied from 2 lit/min to 3.5 lit/min and cooling range for this flow rate has been calculated. It is obvious from fig. 2(b) that water flow rate and cooling range has direct relationship with each other at constant inlet water temperature of 45°C.

Fig. 2(c) is the set of experiments performed on bench top cooling tower to check the relationship between water flow rate and cooling range at constant inlet water temperature of 50°C. Water flow rate has been varied from 2 lit/min to 3.5 lit/min and cooling range for this flow rate has been calculated for each value. It is obvious from fig. 2(c) that water flow rate and cooling range has direct relationship with each other at constant inlet water temperature of 50°C.

Three set of experiments has been performed at three different water inlet temperatures i.e. 40, 45 and 50°C and effect of water flow rate on cooling range has been calculated for each set of experiments. It is obvious from Fig. 2 that water flow rate is directly proportional to cooling range.

### 3.2 Effect of water inlet temperature on cooling range

Fig. 3 is the table between water inlet temperature and cooling range. Effect of water inlet temperature on cooling range has been studied by keeping water flow rate constant. Firstly water inlet temperature has been set at 30°C with constant water flow rate of 1.8 lit/min. water inlet temperature has been varied from 30°C to 50°C and cooling range for each value has been determined.

Fig. 3 is the graph of water inlet temperature and cooling range. Water inlet temperature is on the horizontal axis while cooling range is on vertical axis. Graph is the straight line which means that with the increase in water inlet temperature, cooling range increase. So water inlet temperature and cooling range has direct relationship with each other.

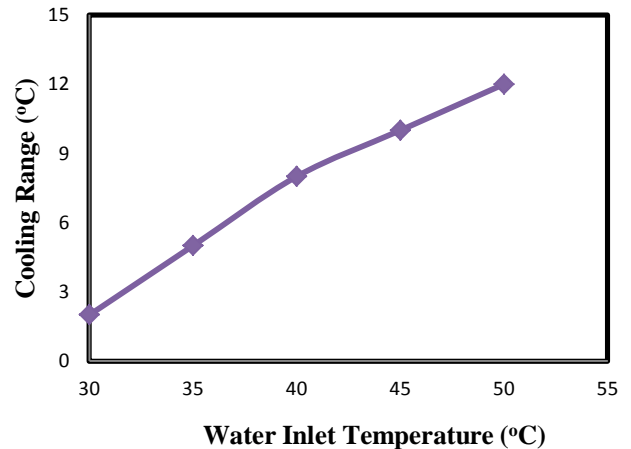


Fig. 3: Effect of water flow rate on cooling range at constant water flow rate

### Conclusion

The aim of this paper is to find the best condition of water inlet temperature and water flow rate for which maximum cooling range appears. The optimum conditions should be selected in such a way that maximum cooling range is achieved.

It is concluded that water flow rate has a direct relationship with cooling range. With the increase in water flow rate, cooling range also increases. Water inlet temperature has also direct relationship with cooling range. With the increase in water inlet temperature, cooling range also increases.

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