Old Wives' Tales

Common misconceptions concerning cooling tower performance

Part 1

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The types of "old wives' tales" that abound in our culture in nearly all walks of life can also be found in the cooling tower industry. In this first part of the article, I will discuss some of the important misconceptions in order to help you achieve the most economical and beneficial application, design, and operation of this important heat transfer device.

Service Factors

Service factors or safety factors are used in the preparation of specifications for most industrial equipment. These can be thought of as multipliers to help ensure that the device will equal or exceed the desired performance. In some cases, the factors are used to increase flexibility. Operation at conditions appreciably different from the design is sometimes made possible in this manner.

CTI Gear Standard STD-111 specifies a minimum service factor of 2.0 for cooling tower right angle spiral bevel gears. In some instances, electrical motors are specified with a 1.1 or 1.15 service factor for cooling tower duty. Likewise, quite often during the design stage of a cooling tower, it is considered appropriate that a service factor be built into the thermal performance capability of the cooling tower.

Consequently, in many instances the numbers presented in a cooling tower inquiry for thermal performance design represent a somewhat more stringent condition than that actually to be encountered in the operation of the unit. This conservative "factor" in the cooling tower design's parameters is certainly not an unjustifiable factor; however, we should give some close attention to where this factor should be applied and its consequent effect on the overall cost of the installed cooling tower.

1. **Lower Cold Water Temperature or Higher Wet Bulb Temperature:** A common misconception is to take the safety factor in the form of lower cold water temperature or higher wet bulb temperature, which in either case reduces the approach (cold water temperature minus wet bulb temperature). This, of course, is an effective manner in

which to take a safety factor.

However, it quite often can be misleading due to the fact that those unfamiliar with cooling tower rating procedures are unaware that closing the approach does not vary linearly with increasing difficulty of duty for the cooling tower, and consequently does not represent a straight-line increase in size or cost. For example, a decrease in approach from 20°F to 19°F would result in an increase in cost of about 5%, while a decrease from 5°F to 4°F would require about 20% more cooling tower.

2. Higher Water Flow Rate: Another scheme that is often used to obtain "safety" is to state a larger GPM (gallons per minute) than will actually be required. Where this method is used, the effect on the cooling tower size and price is essentially a one-to-one or straight-line effect. Hence, a 10% service factor stated as a 10% increase above actual circulating water flow requirements is fairly representative of both tower size and tower cost.

   Nevertheless, one caution must be observed; competent manufacturers will endeavor to design for optimum performance at the inquiry conditions. If the actual operating water loading is appreciably lower, the efficiency of the tower may be markedly reduced due to poor water distribution and/or improper wetting of the fill. Thus, an overzealous effort to obtain a safety factor in this manner could, in some instances, result in an actual loss in performance.

3. Higher Range: The third method used to obtain a service factor is to overstate the range (hot-water temperature minus cold-water temperature) by arbitrarily raising the hot water temperature (HWT) requirement. With this method, it is much easier for the tower to accept additional load and perform satisfactorily when this load is being added in the form of higher hot-water temperature. For most ordinary conditions, an appreciable increase in HWT requires only a relatively small increase in the size and cost of the cooling tower. Consequently, this is usually a good method of obtaining safety.

   Again, there is a caution to be observed. Be certain that the condenser, or equipment being served with this cooling tower water, is capable of taking the higher hot-water temperatures on the leaving sides of the condenser without large adverse effects. This will allow the advantage to be taken of extra performance capabilities built into the cooling tower.

In summary, a safety factor in approach will cause an increase in the cooling tower size and price at a ratio that may be either higher than or equivalent to one-to-one, an increase in GPM is on a one-to-one ratio, and an increase in range is usually less than one-to-one ratio. The most realistic method, then, is a safety factor in water flow. Although not the cheapest, it gives the most flexibility in connection with possible future needs.

"My Tower is Cooling the Water 20°"

Many people have been guilty at one time or another of defining what a cooling tower is doing in terms of range (HWT-CWT). Often, this is accepted as a level of performance of the cooling tower. Nothing could be further from the truth. Heat load in Btu's per hour is equal to 500 times the circulating water flow in gallons per minute times range (Q = 500 x GPM x Range). Now, heat load, of course, is supplied by the unit being served by the cooling tower. The tower itself is neither a heat source nor a heat sink. In the usual circulating system the heat load is independent of the cooling tower.

The number 500 is a constant to convert (GPM/min) to [(1bs/hr) (specific heat)]. Therefore, it is independent of the cooling tower. The circulating water flow in GPM is determined by the number of pumps running and the pressure drop in the overall circulating water system. Therefore, it likewise is independent of the cooling tower. If heat load, the constant, and the circulating water flow are all independent of the cooling tower, then by mathematical deduction the range is likewise completely independent of the cooling tower. Now this at first may be somewhat hard to accept, but a quick recheck of the basic equation will prove the validity of the statement.

Therefore, the range is the same whether there is a two-cell tower or a four-cell tower. The range would be the same if the fans were on full-speed, half-speed, or turned off. Consequently, such a statement as "My tower is not performing because I bought it to cool 20°, and it is only cooling the water 10°" has no validity whatsoever. Likewise, the opposite is also true. Someone who has a cooling tower which is "cooling the water 30°" whereas it was only designed to cool 20°, may not be in such a advantageous position as he might think.

Both these cases show no indication whatsoever of actual thermal capability of the cooling tower. What then is a measure of the thermal capability of the cooling tower? It is not the amount of heat being rejected, rather it is the *level* at which this heat is rejected. *The measure of performance of the cooling tower is the resultant cold water temperature, or even more specifically, the approach (CWT-WBT) under given conditions.* Cold water temperature is the primary dependent variable, and vividly indicates cooling tower capability.

For example, a cooling tower might be designed for cooling water from 110°F to 85°F at a 78°F wet bulb. This gives us a design range of 25°F at an approach of 7°F. If the cooling tower in actual operation is at these temperatures, and at design water circulation rate, then it is performing. However, it could be operating at the conditions of 120°F hot water to 95°F cold water at a 78°F wet bulb and design GPM. In this instance the cooling range would be the same 25°F. So it could be said that the cooling tower was cooling the water 25°F in strict accordance with design. However, the approach would have opened up from 7°F to 17°F, and this cooling tower would be operating at about 50% of the original performance design.

We often blame the cooling tower or praise it, when in truth, all we are seeing is a reflection of the percent of design heat load at which the unit is being operated. Therefore, a unit being operated at 50% over its design capacity will automatically load the tower to 50% over design range as long as the water flow is maintained constant. However, this by no means indicates the tower is operating at a 50% increased capability over its design. The tower will naturally and automatically cool the water through whatever range is being demanded by the unit.

If we want our cooling tower to be upgraded, we must always add to our request -for additional heat load capacity- with one further specification: namely, the cold water temperature, or more specifically, the approach. Therefore, at a given heat load and WBT, the temperature level at which the heat is rejected is the measure of the performance.

Conclusion

I hope the above has demonstrated that cooling tower performance and operation are not so straightforward as they many times are thought to be. These misconceptions or "old cooling tower tales" can cost you money in all phases of dealing with cooling towers.

Purchase of a new tower will cost more than necessary if an inappropriate safety factor is specified. Upgrading an existing tower may turn out to be futile because tower performance was viewed in terms of range. It is necessary to have a working knowledge of the performance of cooling towers, without misconception, in order to purchase and operate them to the best advantage for maximum production at minimum cost.

Thank you! If you have questions or comments, feel free to email me at oshuja@cyber.net.pk, or call me at Jalal Engineering at [021] 636-1960, 680-6374.