Technical science and innovation

Volume 2020 | Issue 3 Article 6

9-30-2020

THE WAYS OF RATIONAL USE OF COOLING TOWERS

D. N. Muhiddinov
Tashkent State Technical University, raximshokirov3@gmail.com

S. Sanayev
Tashkent State Technical University

B. B. Boliyev
École spéciale des travaux publics, du bâtiment et de l'industrie

Recommended Citation
Muhiddinov, D. N.; Sanayev, S.; and Boliyev, B. B. (2020) "THE WAYS OF RATIONAL USE OF COOLING TOWERS," *Technical science and innovation*: Vol. 2020: Iss. 3, Article 6.
DOI: https://doi.org/10.51346/tstu-01.20.3-77-0070
Available at: https://btstu.researchcommons.org/journal/vol2020/iss3/6

UDC 62-714.71

THE WAYS OF RATIONAL USE OF COOLING TOWERS

D. N. Muhiddinov[1*], S. Sanayev[1], B. B. Boliyev[2]

[1]Tashkent State Technical University

[2]École spéciale des travaux publics, du bâtiment et de l'industrie, France

Abstract*. In order to improve the economic performance of the company, the establishment of rational water use schemes and the reduction of the use of fresh water obtained from water supply systems or natural bodies of water can become an important factor. Water-cooling circulating systems, where cooling towers are used as cooling facilities, are the basis of rational water use systems. In water recycling systems that need stable water cooling at high specific hydraulic and thermal loads, cooling towers are used. By spraying water with nozzles or irrigation devices, the surface of water needed to cool it by contact with air is formed. A cooling tower is a heat exchange device for removing heat from various production processes to the environment by evaporating part of the water passing through it. The share of evaporated water usually does not exceed 1.5 %. Most of the cooling towers used were built 30 - 50 years ago. Almost all of these installations are morally and physically outdated. To consider the main criteria that should be guided with the choice of method for reconstruction of cooling towers to increase the efficiency and effectiveness of their operation.*

Keywords: *cooling tower, rational cooling tower type selection, cooling tower renovation, cooling tower maintenance, cooling tower types.*

INRODUCTION. The operating cooling tower must meet several requirements-technical, operational and economic. In process cycles where chilled water is used to produce final products. for example, chemical and petrochemical production, production of mineral fertilizers, dairy industry, incorrectly selected cooling method or incorrectly designed cooling tower can reduce the output of the final product by 1.5-2 times while simultaneously reducing the quality of products. This problem becomes particularly acute in the summer since the efficiency of the production process depends directly on the temperature of the chilled water. [2].

Analysis of publications. There is a misconception that any cooling tower will be optimal or at least meet the needs of a specific production process. It is known that the operating costs during the existence of the cooling system (usually this period is 15-25 years) are many times higher than the capital costs of its creation. [2:3].

Usually, the high temperature of cooling water is associated with either the wrong choice of a cooling tower or its poor technical condition [1-4].

The issue of energy-saving in recycling water supply systems can be considered in the following sections:

- rational choice of cooling tower type:
- compliance of the cooling tower with the object to be cooled:
- cooling tower maintenance;
- reconstruction of the cooling tower.

PURPOSE OF THE ARTICLE. Consider the main criteria that should be followed when choosing a method for reconstruction of cooling towers to improve the efficiency and rationality of their operation.

RESEARCH MATERIALS. The main criterion that should be followed when choosing the method of reconstruction of a cooling tower is a rational choice of its type.

The choice of the type and size of the cooling tower affects the efficiency of the cooling system and, consequently, its energy consumption.

The use of cooling towers with a countercurrent water and air supply scheme allows you to minimize energy consumption in the cooling tower - pumping station complex.

A serious problem in the operation of a cooling tower is air recirculation, when warm and humid air coming out of the cooling tower, which is practically not able to cool the water, re-enters the entrance Windows of the cooling tower. This phenomenon significantly worsens, and even practically stops cooling the recycled water.

Water temperature at the outlet of the cooling tower. all other things being equal, for cooling towers with a counter-current scheme, it is approximately 2 °C lower than for cooling towers with a transverse water and air supply scheme. Similarly, hypothermia. that is the difference between the water temperature at the outlet of the cooling tower and the temperature of the wet thermometer - the physical limit of cooling.

Cooling towers with a counter-current water and air supply scheme have greater cooling efficiency and lower energy consumption. than cross-current cooling towers.

Here are three main elements that determine the effective cooling of water in a cooling tower:

1) uniform distribution of water on the surface of the cooling tower sprinkler;
2) uniform and sufficient amount of airflow;
3) highly efficient sprinkler and drop separator.

Uniform distribution of water, but the surface of the cooling tower sprinkler

To solve this problem, the most suitable are the so-called integral flare nozzles-injectors, which create a filled with drops of water when spraying the torch, which allows you to reduce the number of nozzles-injectors on the cooling tower and simplify the system of pipelines in the distribution network.

A large amount of air supplied to the cooling tower will reliably cool the water, but it will inevitably lead to an increase in energy consumption for the fan drive and an increase in drip entrainment due to an increase in the air velocity at the outlet of the cooling tower. With a small amount of air, a serious problem will be to ensure uniform distribution of air across all the cells of the sprinkler and. as a result, it is possible to provide the required degree of water cooling. The main way to solve these problems is a thorough aerodynamic study of the details of the cooling tower body with dust to reduce drag and reduce vortex formation.

The sprinkler is the main element of a modern cooling tower that provides cooling of recycled water. The drop separator is the second most important element of the cooling tower since the removal of water drops in its absence can reach up to 5 % of the volume of water entering the cooling tower. When the sprinkler is destroyed, part of the air, bypassing the remaining cells, without cooling the water, is removed from the cooling tower, as a result, the degree of cooling of the water decreases. When the separator drop is destroyed, losses increase due to the removal of droplets, since the aerodynamic resistance decreases at the point of destruction of the separator drop, and the air leaves the cooling tower at a high speed along with the drop moisture.

The next criterion for the rational choice of a cooling tower is whether the cooling tower corresponds to the object being cooled.

A cooling tower chosen for cooling the water of any industrial facility must provide water cooling at nominal or even maximum thermal load in the most adverse environmental conditions determined by the climate data of the region. Here you must specify that the heat source is so, which needs to be removed to the environment, it is desirable to divide between 2-3 similar cooling towers. this will ensure that the cooling tower can be regulated.

Saving energy resources is possible in the cooling tower-cooled object system, provided that the correct selection of equipment is selected, and their coordinated operation is the key to reducing operating costs. At the same time, only the correct choice of the type of cooling tower, sprinkler, and fan will allow you to get a workable system that will flexibly respond to changes in both external conditions and the heat load from the production process.

If these methods are followed, the following indicators of various water-cooling methods are possible (table 1).

Table 1

Indicators of various water-cooling methods

Cooler	scope of application of the water cooler		
	Specific heat load thousand W/m^2	Water temperature difference, °C	The difference between the temperature of chilled water and the temperature of atmospheric air on a wet thermometer, °C
Fan cooling towers	(80-100)x1,163 and more	3-20	4-5
Tower cooling towers	(60-100)x1,163	5-15	8-10
Splash pools	(5-20)x1,163	5-10	10-12
Reservoirs coolers	(0,2-0,4)x1,163	5-10	6-8
Radiator (dry) cooling towers	-	5-10	20-35
Open way	(7-15)x1,163	5-10	10-12

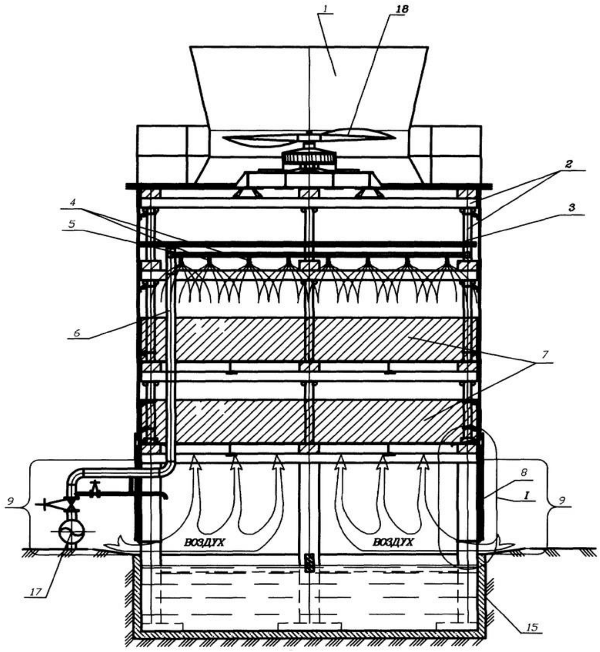


Fig.1. Fan cooling tower section (area 64 m^2)

1-corpus: 2- fan: 3- water distribution system: 4- sprinkler*:*

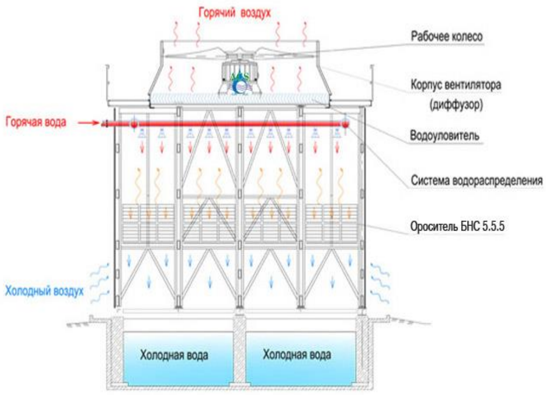
Refrigeration units are equipped with sectional ventilation cooling towers. The cooling tower consists of several identical sections and has a separate cooling water tank. The frame is made of reinforced concrete elements, the tank is made of monolithic reinforced concrete. The outer and inter-sectional paneling is made of asbestos-cement wavy sheets of reinforced profile.

Each section of the cooling tower (Fig. 1) is equipped with a panel or film sprinkler. water distribution system, water-collecting grids, and a fan. installed on the upper floor. According to the standard design, the 64 m^2 sections have the following characteristics:

- the area of the film (for the film the sprinkler) - 9 730 m^2
- height of the sprinkler panels-3.5 m:
- thickness of the sprinkler elements 0,008 m
- the size of the gap between the elements of the sprinkler-0.02 m:
- airspeed in the section:
- with film sprinkler-3.0 m/s:
- with drip irrigation-2.4 m/s:
- the speed of movement of the water film on the elements of the film sprinkler - 0.25 m/s.

Usually, cooling towers of this type of section consist of 4-8 sections, the minimum number of sections is 2.

The choice of the type and size of the cooling tower has a very large impact on the efficiency of the cooling system and, consequently, on its energy consumption. Let's look at some of the most common types of cooling towers (Fig. 2-5).



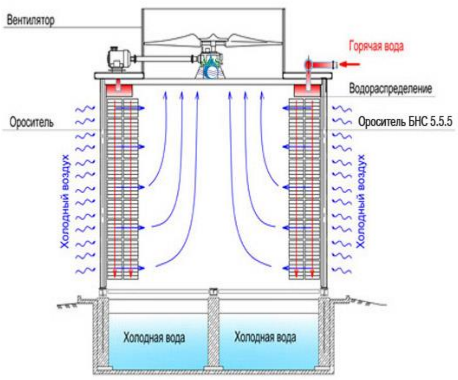


Fig-2: parallel flow evaporative cooling system, Fig-3: cross-flow system

This type of cooling tower (Fig. 2) operates without a fan, without a tree or a staircase, without a flat stream, without an electric cable laying or electric connection of the driving force the Principle is simple: water that needs to be cooled is injected into the cooling tower by sprayers that provoke air induction into the container of the mixture. the heat of the water is transmitted by air under the influence of cooling by the evaporator. So the cooled water enters the recovery pool, the air is removed by the device to reduce the drop formation.

Cross-flow (mixed) cooling towers use the same cooling principle by evaporating a small amount of water. Water is distributed over the surface of the jet cooling system. The air is removed by convection, passing through the exchange area (Fig. 3). this way the cooled water enters the recovery pool.

These cooling towers can be easily applied to installations with low energy consumption, as well as in solving problems with height. The shaft, heated during the cycle, is introduced into the cooling tower along the upper distribution trestle, equipped with pulverizes (Fig. 4). Water is uniformly dispersed in thin droplets. then it flows down to the exchange square. Air intake in the cooling tower is forced. As a result of partial evaporation and convection, the water temperature drops. In the end, the cooled ox enters the recovery pool.

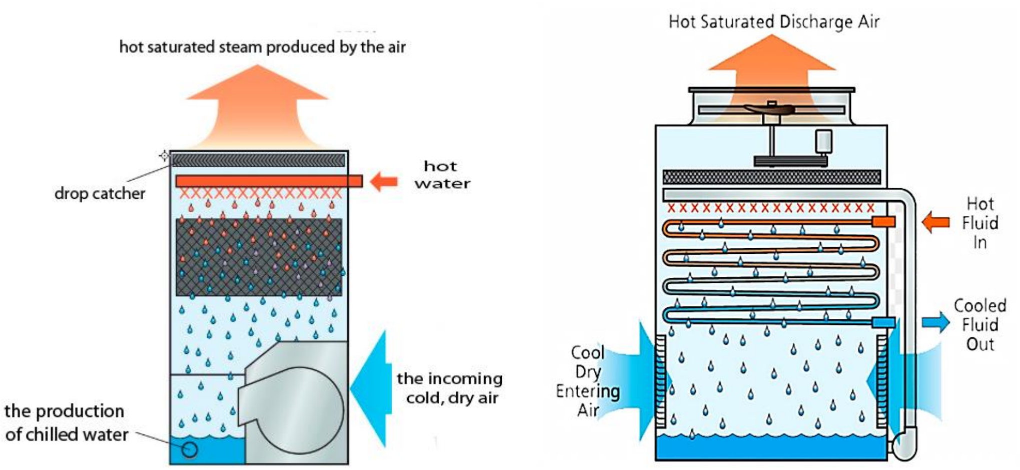


Fig -4. System with centrifugal fan – a: screw the fan system (spiral) – b:

The liquid body that was cooled circulates inside a heat exchanger placed in a large part of the cooling tower (fig - 5).

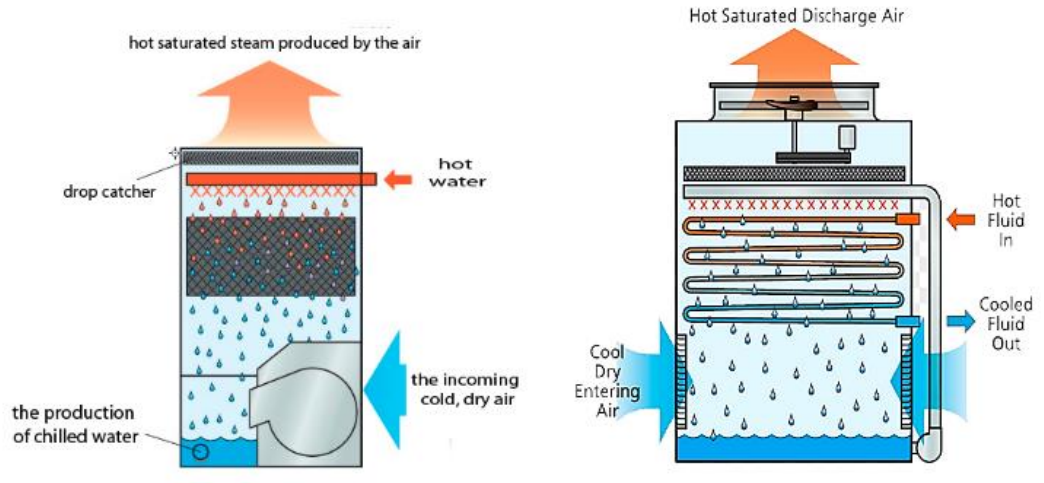


Fig – 5. Closed-cycle cooling system

The pulverize trestle, located above the heat exchanger, allows the water in the stream to fall under its weight and thus cools the pipes. The heat of the liquid body, which must be cooled, is transferred to the water flow through the partitions of the pipes. The air is supplied by forced distribution. provoking the evaporation of a small percentage of water, the flow, thus taking away the latent heat of evaporation. The water in the flow enters the recovery pool and re-circulates along the overpass of the sprayers using a pump. Water droplets involved by parity are stopped by droplet switches placed on top of the apparatus and fall back into the pool. Water consumption is limited to the vaporized amount, a much smaller volume, which (3) is purified to limit the concentration of impurities in the pool.

For a film cooling tower, the minimum specific hydraulic load per 1 linear meter of the Sprinter (g_w) shield that provides a stable water film is 0.12 $m^3/(m*h)$. The most effective cooling of water is achieved when the following conditions are met:

$$\Delta t = t_{w2} - t_{m1} = 0, \quad (1)$$

Where, $\mathbf{t_{w2}}$ the final temperature of the cooled water. °C:

$\mathbf{t_{m1}}$ **-** the temperature of the ambient air wet-bulb temperature. °C:

Specific hydraulic load per 1 linear meter of the sprinkler shield:

$$g_w = \frac{G_w H}{F_f} \quad (2)$$

where G_w - cooling water consumption, kg/h:

H - the height of the sprinkler, m:

F_f - the area of the water film, m^2:

From equation (2), you can determine the minimum allowable flow of cooling water. Maximum specific air consumption:

$$\boldsymbol{\lambda_{max} = \frac{V_f * \rho}{G_w * 10^3}} \quad (3)$$

Where $\boldsymbol{V_f}$ **-** fan performance, m^3/h:

$\boldsymbol{\rho}$ – 1.25 kg/m^3 - the average density of air

Minimum specific water consumption (irrigation coefficient):

$$\mu_{min} = \frac{1}{\lambda_{max}} \qquad (4)$$

The coefficient of water cooling efficiency was defined as the ratio of its cooling value to the theoretical cooling limit:

$$\eta_A = E = \frac{t_{w1} - t_{w2}}{t_{w1} - t_{m1}} \qquad (5)$$

CONCLUSION. Having Analyzed various ways of rational use of cooling towers. we determined the coefficient of water-cooling efficiency as the ratio of the water-cooling value to its theoretical cooling limit. Energy Efficiency is possible only in the cooling tower - cooled object system, so the correct selection of equipment and their coordinated operation is the key to reducing operating costs. At the same time, only the correct choice of the type of cooling tower, sprinkler, and fan will allow you to get a workable system that will flexibly respond to changes in both external conditions and the heat load of the production process. Maintenance involves several measures, the main of which include methods for cleaning all elements of the cooling tower from contamination. Clogging of the nozzle nozzles and the surface of the sprinkler. water distribution of pipelines leads to a decrease in the efficiency of cooling processes. Execution of reconstruction works; it is expedient if the cooling tower can survive for at least another 10-15 years. otherwise, it is easier to replace it with a new device. Before starting the reconstruction, make sure that. that upon completion of the planned activities, the cooling tower will correspond to the equipment that needs cooling.

References

1. Thom, H.C. S “The Rational Relationship Between Heating Degree Days and Temperature” Monthly Weather Review, Department of Commerce 82(1) 2003
2. U.S. Department of Energy, Building Energy data book, 2010 tables, http://buildingsdatabook.ener.doe.gov/ChpterIntro1.aspx, 2011
3. Ivanov V. B. New technologies cooing fluids m packed towers - Energy security and energy efficiency. Moscow. 2009. no 2. pp. 25 - 28. (in Russian).
4. Ochkov V.F. MathCad 14 dlya studentov i injenerov: russkaya versiya. – BHV-Peterburg, 2009. 256 s.
5. Prilepskiy D.V. Sovershenstvovaniye system kondisionirovaniya vozduxa s ispol’zovaniyem kameri orosheniya s poperechnim raspolojeniyem forsunok. Av-t. diss. kan. texn. nauk. Volgograd, 2014. – 150 s.
6. Kagan A.M., Laptev A.G., Pushnov A.S., Faraxov M.I. Kontaktniye nasadki promishlennix teplomassoobmennix apparatov. Monografiya. Pod red. Lapteva A.G. – Kazan’: Otechestvo, 2013, - 454 s.
7. Zhang L. Total Heat Recovery. Heat and Moisture Recovery from Ventilation Air / L. Zhang // Nova Science Publishers Inc. – N.Y., 2008. – 327 p.

8. Xomutskiy Yu.V. Raschet kosvenno-isparitel’noy sistemi oxlajdeniya / Yu.V. Xomutskiy // Mir klimata. – 2012. № 71. – S. 174-182.
9. Shilyayev M.I., Xromova Ye.M., Grigor’yev A.V., Tumashova A.V. Gidrodinamika i teplomassoobmen v forsunochnix kamerax orosheniya // Tomskiy GASU, 2011. №1, S. 15-26.
10. Usmonov N.O., Umarova M.X. Intensifikasiya teplomassoobmen v apparate psevdoojijennogo sloya s sharovoy nasadkoy // Jurnal TashGTU Vestnik, 2018. №3, S. 96-101.
11. Isaxodjayev X.S., Usmonov N.O., Umarova M.X., Maxmudova D.X. Opredeleniye koeffisiyenta teplootdachi ot trexfaznogo psevdoojijennogo sloya k stenke apparata oxlaajdeniya vodi // Jurnal «Problemi energo- i resursosberejeniya» 2018. № 3-4, S. 202-205.
12. Usmonov N.O, Mavjudova Sh.S. Teploutilizator v sistemax ventilyasii i kondisionirovaniya vozduxa // Mejdunarodnaya nauchno-prakticheskaya konferensiya. «Innovasii-2018», Tashkent, S. 89-91.
13. Kochetov O.S. Primeneniye apparatov kipyashego sloya dlya system ventilyasii // Mejdunarodniy nauchniy jurnal «Simvol nauki», 2016. №4. S. 83-85.
14. Kirsanov V.V., Ignakin I.Yu. Matematicheskaya model’ vodoisparitel’nogo oxlajdeniya v sistemax ventilyasii // Vestnik Texnika i texnologii APK, Moskva, 2017. №1. S. 14-20.
15. Kimenev G.N. Rasional’noye ispol’zovaniye topliva i energii v pishevoy promishlennosti. – M.: AO «Agropromizdat», 1990. – 168 s.