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COMPARING THE NOISE CHARACTERISTICS OF DIFFERENT TYPES OF COOLING TOWERS

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***Abstract**: Comparing the noise characteristics of natural draft counterflow cooling towers during their operation with dry cooling towers at the same cooling capacity carried out. The difference in the reasons for the noise generation of natural draft counterflow cooling towers in comparison with dry cooling towers showed. A condition obtained for the pressure of axial fans for octave bands and for the sound level in dBA, when dry cooling towers emit sound energy more than natural draft cooling tower. It shows that dry cooling towers are noisier than natural draft cooling towers for the same cooling capacity.*

***Keywords:** noise emission, natural draft cooling tower, dry cooling tower*

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1. INTRODUCTION

Cooling towers uses in many enterprises to cool water. The wide use of it is due to their placement requires much smaller area comparing to other types of coolers. For power engineering, powerful natural draft counterflow cooling towers use. Also, more and more dry cooling towers use [1-5]. In natural draft counterflow cooling towers, cooling carries out due to the evaporation of part of the water when it falls. In dry cooling towers, water flows through heat exchangers and cools by air, which pumps by fans. At the same time, there is no water loss, which makes the use of these cooling towers attractive. There are other types of cooling towers that combine the cooling principle of these two types of cooling towers. The noise from the operation of cooling towers can exceed sanitary standards [6]. This is especially true for combined heat and power plants, which locates near residential areas [7].

Together with the increase in the unit capacity of the turbines, the productivity of the cooling towers also increases. At powerful thermal power plants (TPPs), cooling towers with a capacity of 52,000 m^3/h are operating. Also, larger ones with a capacity of about 100,000 m^3/h (with a tower height of 150 m) are designing. It is important to consider the factor of noise impact building such cooling towers.

The purpose of this paper is to compare the radiated sound energy from natural draft counterflow cooling towers with dry cooling towers. They have the same cooling capacity. This is relevant given that dry cooling towers are currently planning as an alternative to natural draft counterflow cooling towers.

2. NOISE FROM NATURAL DRAFT COUNTERFLOW COOLING TOWERS

Noise in natural draft counterflow cooling towers causes the water to fall (Fig.1). The emitted sound power is proportional to the water flow rate, the speed of the water droplets at the moment of falling and the depth of the water in the pool. At high building densities, the noise from these cooling towers can become an important component of the background noise.

The noise spectrum of counterflow natural draft cooling towers has approximately equal characteristics for octave bands from 500 to 8000 Hz and reduced for octave bands frequencies less than 500 Hz. The sound level at 1 m from the windows of the cooling towers is in the range of 80-87 dB(A) (Fig. 1 a). Louvers install on the cooling towers to reduce the air flow in winter. It reduces the sound level by 2-3 dB(A).

Most of the sound energy emits from natural draft counterflow cooling towers through the intake windows (Fig. 1 b). The noise level at the top of such cooling towers is at least 10 dB less than that of the entrance windows. Sound radiation through the shell of these cooling towers neglects.

As the depth of the cooling tower pool decreases, the level of radiated sound energy decreases. So, it is recommendation to make basins with a cone-shaped bottom that allows water to drain to the edges of the cooling tower basin. The irrigated part of the bottom has a minimum depth [7].

a) b)

Fig. 1: Natural draft counterflow cooling towers: a —construction; b— intake windows

3. NOISE FROM DRY COOLING TOWERS

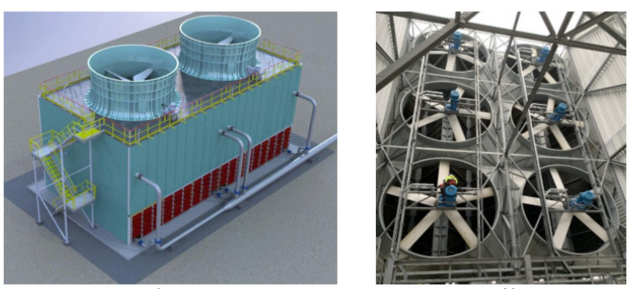
Noise from dry cooling towers determines by noise from axial fans (Fig. 2). In this case, the number of fans depends on the thermal power of the cooling tower and can range from one or two (Fig.2a) to several dozen (Fig.2b). Fans for high-power cooling towers can install in several rows above each other. Sound energy, unlike natural draft counterflow cooling towers, emits from the fan's suction system. Sound levels at 1 m from the dry cooling towers are 85 - 90 dB(A).

The noise from axial fans is aerodynamic in nature. The noise in the fan spectrum prevails at the octave bands of 63-500 Hz.

In a designed and operated axial fan, the mechanical noise from the bearings, as well as the noise of the gearbox transmits along the walls of the cooling tower structures (structure-borne noise), is usually insignificant.

Sound energy from dry cooling towers increases as the number of fans and their performance, volume flow and especially total pressure increase. The level of the radiated sound power of the fan depends on the fan tip speed, fan diameter, and the shape of the blade [7-8].

Fig. 2: Dry cooling towers: a— low power; b —high power



a) b)

4. COMPARING THE NOISE CHARACTERISTIC OF COOLING TOWERS

Sound power levels, dB, in octave bands from natural draft counterflow cooling towers at the air intake point calculates using the well-known formula [7]:

$$L_{W\,CTi} = L_{CTi} + 10 \cdot lgq \qquad (1)$$

where

q - water volume flow, m^3/h;

L_{CTi} - correction, depending on octave bands, dB.

The correction values depending on octave bands are presented in Tab. 1.

Octave bands, [Hz]	Value (L_{CTi}) [dB]
63	51
125	51
250	51
500	57
1000	62
2000	62
4000	63
8000	61

Tab. 1: Correction (L_{CTi}), depending on the octave bands

Sound level, dB(A), from natural draft counterflow cooling towers calculates according to the formula [8]:

$$L_{W\,CTA} = 68 + 10 \cdot lgq \pm 2 \qquad (2)$$

where

q - water volume flow, m^3/h.

Sound power levels from axial fans of a dry cooling tower calculates according to a well-known formula depending on the total pressure H, Pa, and the volumetric air flow Q, m^3/s [10]:

$$L_{W\,f} = \bar{L} + 10 \cdot (l + \alpha/2) \cdot lgH + 10 \cdot lgQ \qquad (3)$$

where

$\bar{L}$ - noise criterion, dB,

α - coefficient depending on fan tip speed u, m/s, and fan diameter

D, m, as follows:

α = 1 if u = 5-15 m/s;

α = 2 if u= 20-50 m/s и D = 0,4-1,2 m;

α = 3 if u > 50 m/s и D= 1,2-20 m.

For most axial fans used in power engineering, α = 3. Noise criterion ($\bar{L}$) for axial machines is equal to 52 dB [10].

The sound power level for axial fans of 06-300 type for octave bands at a speed of $\boldsymbol{n}$ = 700-1400 rpm determines by the formula:

$$L_{W\,fi} = \bar{L}_{W\,f} - \Delta_i, \qquad (4)$$

where
Δ_i - correction, depending on octave bands, dB.

The correction values depending on octave bands are presented in Tab. 2.

Octave bands, [Hz]	Value (Δ_i), [dB]
63	13
125	8
250	8
500	5
1000	7
2000	9
4000	15
8000	23

Tab. 2: Correction (Δ_i), depending on octave bands.

In [8], the sound power level from axial fans, dB(A), for a fan cooling tower at the inlet to the cooling tower calculates depending on the air volume flow $\boldsymbol{Q}$, m^3/s, and the fan pressure drop Δ_p, hPa:

$$L_{W\,fA} = 16 + 10 \cdot lg(Q/Q_0) + 20 \cdot \Delta p/\Delta p_0 \pm 5 \qquad (5)$$

where
Q_0 = 1 m^3 of air/h;
Δp_0 = 1 hPa (10^{-2} Pa).

Air volume flow Q, m^3/s, depends on the amount of cooling water q, m^3/h, according to the following formula:

$$Q = m \cdot q \qquad (6)$$

where
$\boldsymbol{m}$ - circulation rate. The circulation rate is much greater than $\boldsymbol{m}$>>1.

Dry cooling towers will noisier if:

$$L_{W\,f} - L_{W\,CT} > 0 \qquad (7)$$

From formulas (1) - (7) we get the pressure $\boldsymbol{H}$, Pa, at which dry cooling towers will noisier than natural draft counterflow cooling towers for octave bands

$$H > 10^{\frac{L_{W\,CTi} - L_{W\,f} + \Delta_i - 10 \cdot lgm}{25}} \qquad (8)$$

And by the sound level, dB(A), $\boldsymbol{\Delta p}$, hPa, determines by the following formula:

$$\Delta p > \frac{52 - 10 \cdot lgm}{20} \qquad (9)$$

Estimated calculation according to (8-9) shows that the critical value of H does not exceed ten Pa. For power cooling towers, fans create a pressure of hundreds and thousands of Pa. So, dry cooling towers will noisier than counterflow natural draft cooling towers. This circumstance must take into account when designing and building such cooling towers.

The use of dry cooling towers will must the adoption of measures to reduce noise from both TPPs with steam power and steam-gas equipment [11-14].

5. CONCLUSION

1. Cooling towers can cause exceeding of sanitary norms for noise in the surrounding area. Natural draft cooling towers and dry cooling towers use in TPPs most. Dry cooling towers currently considers as an alternative for natural draft cooling towers.
2. A condition obtained for the pressure of axial fans (8) in octave bands and (9) for the sound level, when dry cooling towers emit sound energy more than a natural draft cooling tower.
3. Dry cooling towers are noisier than natural draft cooling towers for the same cooling capacity.

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