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# Temperature and Humidity Parameters of The Air Environment in Industrial Premises

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## ABSTRACT

In hac charta, dependentiam physica et mechanica proprietates fibris et filis (possidet serico) in humiditas aeris environment cursus praemissis habetur, in particulari, quae ducit ad violatione requisitis urna caeli et humiditas environment discursum uber, maxime proprium parametri quod descriptam caeli humiditas etiam datum.

**Keywords:** Humiditas, irritum onere, elongationem de fibris, de fractura fibris, absoluta humiditas, humorem content – pondus, umor contentus, - volume, partialis pressura (elasticitas) ex aqua vapor, ros tortor, relative humiditas.

The widespread use of new technology, the improvement of technology and the automation of most industries are closely related to the state of the vapor-air environment, primarily with its heat and moisture content.

Physical and mechanical properties of fibers, threads (including silk), in the production of fabrics largely depend on the humidity of the environment in industrial premises. As a rule, a change in the temperature and humidity parameters of the air environment leads to a change in such properties of the threads as breaking load and elongation, which, along with the violation of the requirements for the parameters of the air environment and the humidity of the workpiece, lead to an increase in breakage in the weaving industry.

textile and silk-winding factories during each hour of work there are up to several thousand breaks of threads in the weaving industry. The elimination of such a mass of cliffs takes a significant amount of time of several thousand workers. About 45% of all workers employed, for example, in the wool industry, work in the weaving industry [1].

Maintaining air conditions at the required level helps to reduce thread breakage in weaving [2], allows rational use of air conditioning systems, the initial costs of which reach 12% of the total cost of the structure, and the annual operating costs reach 40% of production [ 3].

Automatic measurement of temperature and humidity parameters of the air in industrial premises is a complex physical and technical problem.Its solution is associated with the use of electrical methods for measuring such non-electrical parameters as temperature and humidity.

As you know, atmospheric air mainly consists of a mechanical mixture of nitrogen (~ 78%) and oxygen (~ 21%) with a small admixture of argon (~ 1%), carbon dioxide (~ 0.3%) and an insignificant amount (~ 2 * 10-3%) of noble gases and azone. Of course, the composition of the air in cities, and even more so in various closed industrial premises, can differ greatly from the given composition of atmospheric air. Nevertheless, in most practical calculations, air is considered an ideal gas with a molecular weight of 29 g / mol.

Depending on the intensity of the processes of evaporation and sublimation, including as a result of the vital activity of animals and plants, human activities, the air contains that or other amount of water vapor.

At present, air humidity is usually characterized by various physical quantities, of which the most characteristic are: absolute humidity "α" (g / m3) (density of water vapor); moisture content - weight "d" (g / kg) or volume "Xppm"; partial pressure (elasticity) of water vapor (mm Hg), dew point temperature "τ" (0C) and relative humidity "φ" (%) [1].

Such a variety of characteristics of air humidity indicates the fact that humidity is a complex parameter and in different conditions, measurements do not appear in the same way. It is characteristic that all these concepts are physically heterogeneous and they cannot be connected with each other by linear dependence, like ordinary physical parameters when transferred to another measurement system.The characteristic can be conservative in relation to some air parameters or depend on them, it can be conservative in relation to closed systems or vice versa [4,5]. An open system means a system that contains humid air in a certain volume and communicates with a system of a significant large volume; a closed system means an isolated system.

The absolute air humidity "α" can be related to other physical parameters of the air using the equation for an ideal gas:

$$\alpha = K e / RT, \quad (1)$$

where: K is the proportionality coefficient;

R is the universal constant of water vapor;

T is the air temperature, K;

is the e-elasticity of saturated vapor.

In closed systems, a change in temperature causes a corresponding change in the pressure in the system and in the elasticity of water vapor, while the air density does not change, i.e. α = Const, absolute air humidity becomes conservative to temperature. A change in pressure in a closed system at a constant temperature causes a change in the elasticity of water vapor, and therefore, in absolute humidity. In open systems, the pressure is determined by the ambient pressure. Under these conditions, the density of water vapor, as follows from equation (1), depends on the temperature and pressure of the medium, i.e. absolute humidity is not conservative with these parameters.

The elasticity of saturated steam "e" or "Pn", and therefore the maximum absolute humidity of the air "a", nonlinearly increase with temperature (Fig. 1).

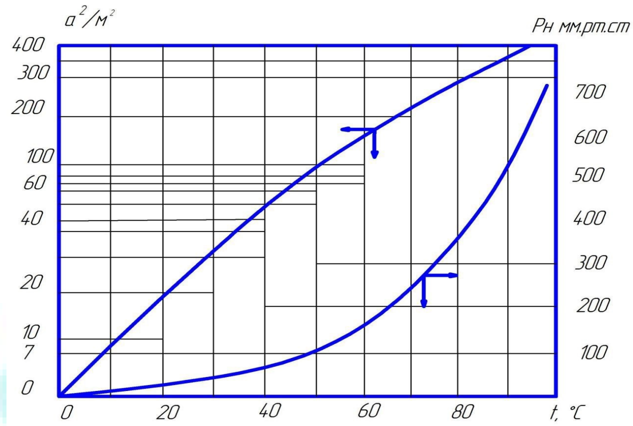


Fig.1. Dependence of saturated vapor pressure "Pн" and absolute humidity "a" on temperature.

In this regard, absolute humidity cannot unambiguously characterize air humidity, i.e. additional information on temperature and pressure of the medium is required. Therefore, this value is mainly used to characterize the moisture content of gases in closed systems and is used relatively rarely (gas industry). Since the density of water vapor is a parameter that can be directly converted into a corresponding signal, there are devices with a scale expressed in terms of absolute humidity.

In most cases, relative humidity is used to characterize air humidity, since the effect of moisture on materials often depend on the value of only this quantity.Relative air humidity is the ratio of water vapor pressure "e" to the pressure of its saturated vapor "E" at a given temperature, i.e.:

$$\varphi = (e / E \cdot 100)\% = (1 / K \cdot (a \cdot R \cdot T) / E \cdot 100)\% \quad (2)$$

Relative humidity, as follows from equation (2), is not conservative with respect to temperature,

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nor in relation to pressure in closed and open systems.

The use of relative humidity in calculations causes some difficulties, since it is associated with the use of a non-linear function E = *f* (T). There are direct methods for measuring relative humidity, since relative humidity affects the properties of materials (changes in size, weight, density, electrical properties, etc.) and therefore a significant number of instruments for measuring air humidity are scaled in terms of relative humidity. {{1 }} The elasticity (partial pressure) of water vapor "e" is in some conditions a more conservative characteristic than absolute or relative humidity. In open systems "e" depends on pressure and does not depend on temperature; in closed systems, the pressure of water vapor is not conservative either to temperature or to air pressure. The value "e" is convenient for practical calculations, since it does not require reduction to standard conditions, as it is necessary, for example, to do in the case of operating with absolute humidity. There are instruments that measure the pressure of water vapor (for example, instruments using the diffusion method).

On the other hand, according to the Cliperon-Mendeleev equation for steam and air, taking into account the molecular weights of steam Mn = 18g / mol and air MV = 29g / mol, the expression for the moisture content can be written as:

$$d = m\_p / m\_c = ⟦18P⟧\_p / ⟦29P⟧\_s = 0.622 P\_s / (P\_b-P\_p) \qquad (3)$$

where:

mp and mc - mass of water vapor and dry air, respectively;

Pp and Pc - partial pressure of vapor and dry air (gas), respectively;

Pb - barometric pressure, which according to Dalton's law Pb = Pc + Pп.

Considering that the relative humidity is equal to:

$$φ = P\_п / P\_н, \qquad (4)$$

then equation (3) for moisture content can be written as:

$$d = 0.622 · (φ · P\_n) / (P\_b-φ · P\_n), \qquad (5)$$

or, whence

$$φ = P\_b / P\_н · d / (0,622 + d), \qquad (6)$$

where:

Pн - saturated steam pressure.

From equation (6) it can be seen that the relative humidity of the air depends not only on the moisture content, but also on the barometric pressure and on the pressure of the saturated vapor. According to formula (5), the relationship between d, φ, P_ (b) and P_n is nonlinear (Fig. 2).

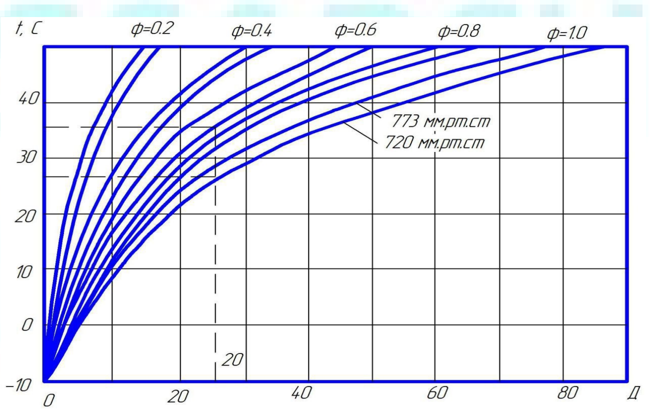


Fig.2. Simplified diagram of humid air for barometric pressures from 728 to 773 mm. rt. st.

The so-called parameter - "dew point" (τ), is the temperature at which condensation of water vapor from the air begins and is a form of expression of the elasticity of water vapor. Like the pressure of water vapor, the dew point in closed systems depends on the temperature and pressure of the environment, and in open systems it depends on the pressure, but does not depend on the air temperature. Dew point is a fairly common parameter for gas moisture, especially for characterizing gases with a low moisture content.There are instruments for direct measurement of the dew point. However, this

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parameter is inconvenient for mathematical calculations.

Another parameter - the volumetric moisture content "X" is the ratio of the volume of water vapor to the volume of gas in which the water vapor is located. The ratio of the mass of water vapor to the mass of dry gas, in the same volume, is the weight moisture content "d" (mixture ratio). Moisture content is an absolutely conservative characteristic in relation to the pressure and temperature of air in open and closed systems, however, there are no devices for directly determining this characteristic.

The technology of twisting raw silk and chemical threads is divided into several stages, at each of of which several technological processes are carried out on devices and machines, which are different both in design and in purpose, including the processes of unwinding and preparation for twisting and twisting [6].

The main types of raw materials used in silk-twisting production are chemical threads (viscose, acetate, nylon, lavsan, etc.), as well as metal threads. The quality and quantity of raw materials at the silk-spinning factories is carried out in accordance with state standards or approved specifications.

When accepting raw materials, they weigh (selectively) and check their packaging. If defects are found in the packaging, an act is drawn up.Settlement with enterprises suppliers of raw materials is carried out according to the standard weight, which is determined as:

$$[\![G]\!]\_k = G\_f \cdot (100 + W\_k) / (100 + W\_f), \quad (7)$$

Actual humidity in percent is determined after conditioning using the formula:

$$W = ((g\_ (1) - g\_2)) / g\_2 \cdot 100, \quad (8)$$

where: g_ (1) is the initial mass of the sample, G;

g_2 - constant mass of the sample after drying in a conditioned apparatus, G.

State standards and specifications provide for the following conditional moisture content of raw materials used in silk-spinning production: raw silk-11%; viscose threads-11%; triacetate yarns, 4.7%; nylon threads-1.0%; silk yarn - 5%.

It is known such characteristics (properties) of threads as "relative breaking strength in dry state [mn / tex]"; "Breaking load in a wet state in% to dry"; "Relative elongation in dry condition, in%"; "Relative elongation in a wet state, in%"; "Density [g / cm3]" affects the spinning technology.

The properties of raw silk and chemical filaments largely determine the technological parameters of silk-spinning production. In silk-spinning production, it is necessary to take into account the following specific features of raw materials:

- the degree and nature of the moistening of raw silk, the effect on the intensity of soaking and the composition of the soaking emulsion;

- relatively high unevenness and the influence of external defects in the form of loops, deposits and drowned places in the threads of raw silk. Twisted yarns from this raw material are wound in several stages onto spools at relatively low rewinding speeds of raw silk, often combined with preliminary elimination of defects;

- greater hygroscopicity and a significant decrease in the wet strength of viscose yarns.For this purpose, it is necessary to maintain a constant temperature (18-250C) and humidity (55-60%);

- the ability and electrification of raw materials, especially synthetic threads, to reduce which they maintain a certain temperature and humidity in the workshops; {{1 }} - increased sensitivity of artificial yarns to tensile stress, at which small deformations can occur that worsen the properties of the yarns. Tension regulators, compensators and other devices are installed in the machines to protect the threads from changing loads.

To ensure the normal flow of the technological process and preserve the physical and mechanical properties of the processed raw materials in production facilities, it is recommended to maintain temperature and humidity conditions [7]: { {1}} - with separate processing of various types of raw materials, rewinding of viscose silk, the air humidity in the workshop should be within 50-55%; air temperature + 230C;

- when twisting viscose silk, air humidity should be within 55-58%; air temperature + 230C;

- when processing natural silk, acetate and nylon fiber, air humidity should be 60-65%; air temperature + 230C;

- when all types of silk fibers are processed together, the air humidity should be within 63 ± 3%; air temperature + 230C.

The technological process of the textile (silk) industry occurs (discretely or continuously) in an air environment, the state of which is characterized by temperature t, relative humidity φ, dust content C, chemical composition, flow mobility ϑ, amount of electric charge of one sign or another in a unit of volume and other quantities. Microclimate (in the narrow sense) is usually understood as the totality of only two variables t and φ.

A technological product, passing through the technological chain, constantly interacts with the microclimate m = f (t, φ). The memory of this contact, which has a purely diffusion nature, remains in the form of the moisture content of the product, which ultimately determines the stability and quality of the technological process.

Maintaining the temperature and relative humidity of the air in the required range (t = + 230C) and (φ = 63 ± 3%) is usually carried out mainly by an air conditioning system (ACR) and an air exchange system (SV), as well as an air after-humidification system (AF), and the air conditioning system supplies an air exchange system with well-defined t and φ, while SV provides air distribution in the production area. SDV in the production area is provided to ensure the required value of the relative air humidity, the work of which in most cases is not automated, operates mostly uninterruptedly and is turned off extremely rarely.Such work of the SDV naturally leads to an increase in the relative humidity of the air above the required value, which ultimately leads to an increase in thread breakage during twisting, the elimination of which takes a significant amount of time for dozens of workers working in this pro In addition, the uninterrupted operation of the SDV, as already noted, if appropriate measures are not taken, will lead to an excessive increase in the relative humidity of the air, and maintaining the relative humidity of the air at the required level will also require the uninterrupted operation of the SCR and SV, which will lead to additional consumption of energy resources.

As can be seen from the above, the properties of the processed raw materials (threads) to a certain extent depend on the temperature and humidity parameters of the air environment of the production room, which will require maintaining the humidity and temperature at the required level.

In order to eliminate of such undesirable phenomena, it is simply necessary to automate the work of the SDV, the work of which will be controlled and regulated by the sensors of the relative humidity of the air [3].

To solve a specific problem, it is necessary to choose such a method of control and regulation of the relative humidity of the air, which would satisfy the requirements. In this regard, the analysis and classification of applied and newly developed methods is of great importance. The systematization and classification of methods for measuring the moisture content of gaseous media (including the air environments of industrial premises) will make it possible to assess the applicability of the methods and their prospects when creating a system of unified moisture sensors for gaseous media.duction.

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