THE ROLE OF THE TEMPERATURE FACTOR
IN CHEMICAL FIBRE TECHNOLOGY

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The thermodynamic definition of a rise in the temperature as a quantity characterizing the thermodynamic equilibrium of a system and the physical equilibrium is examined as a measure of the average kinetic energy of molecules; their limitations are noted. Determination of the temperature as the density (concentration) of electromagnetic energy, which is a function of the frequency and amplitude of vibrations, is proposed. Dissolution and melting of polymers take place under the effect of microwave radiation with a frequency of $10^{10}$-$10^{12}$ sec$^{-1}$ and the far infrared with a frequency of up to $10^{13}$ sec$^{-1}$ on intermolecular bonds, causing them to break and accelerating the kinetic units of the chains (segments) enough to convert them into orbital motion relative to each other in circular and elliptical orbits. Chemical reactions take place under the effect of infrared with a frequency of $10^{15}$, visible, and ultraviolet radiation with a frequency of $10^{16}$ sec$^{-1}$. As a function of the temperature (radiation energy density), chemical bonds can form due to collisions of molecules and capture of molecules of another reagent at rates not exceeding parabolic rates or breaking of bonds if the atoms involved in the bonds have a rate higher than parabolic. When endothermic reactions take place, energy is consumed in breaking of bonds and is conserved in the form of orbital energy, which is considered as entropy in thermodynamics.

The temperature is one of the most important process parameters in production of chemical fibres. It varies from negative values in regeneration of spinning baths by crystallization in production of viscose fibres up to 2500-3000°C during carbonization (graphitization) of high-modulus carbon fibres. However, manufacturing processes most frequently take place at a temperature of 10-100°C in manufacturing fibres from polymer solutions and at 250-300°C from melts.

The effect of the temperature on the manufacturing process is ambiguous. An increase in the temperature usually accelerates the process. However, in addition to acceleration, the yield of target product decreases, consumption of stock for by-products increases, and the quality of the fibre decreases or on the contrary increases. All of this forces a more rational approach to understanding the physical essence of definition of the temperature to deliberately regulate this parameter in implementation of a manufacturing process. Different points of view on this question are analyzed and some examples of the role of the temperature factor in chemical fibre technology are examined here.

The problem of defining the physical essence of temperature is not as simple as it would seem at first glance. There are two approaches to defining the concept of temperature in the literature — thermodynamic and physical. The first is based on the zero origin in thermodynamics, which states: “If two systems are in thermal equilibrium, their temperature will be the same.” Then the thermodynamic definition of temperature, as it is given in an encyclopedia, for example [2]: “A physical entity characterizing the state of thermodynamic equilibrium of a system.” No attempts have been made to give a physical interpretation of the concept of temperature in this official source. In addition, the thermodynamics course in [3] states that such thermodynamic parameters as “temperature and entropy in general do not have any mechanical (physical) meaning.”

The physical approach to defining temperature primarily proposes the physical phenomena (processes) on which the concept is based. The most frequently encountered physical definition of temperature states [4]: “The temperature of a system is a measure of the intensity of movement of all atoms and molecules in the system” or, more precisely [5]: “The temperature is a measure of the average kinetic energy of the molecules of a substance.” The last definition, which is the most widespread, is given in almost any physics or chemistry course. However, this definition cannot be considered satisfactory. The dependence of the kinetic energy of molecules on the temperature is one of the properties manifested when the temperature of a system changes. We can also say that the temperature is a measure of the thermal expansion of a body or measure of the intensity of radiation. At the same time, both of these properties are used for measuring temperature. Many other processes are a function of the temperature and can be used to define it. For this reason, it is necessary to search for something in common at the basis of all these changes.

In considering the question, it is necessary to take into account that temperature is primarily energy. This follows from the above definition of the temperature as kinetic energy. Input of energy is also the basis of thermal expansion and radiation. The unit of measurement of temperature — the degree — is an arbitrary entity. It is 0.01 part of the scale between the solid and boiling points of water. If we use a scale in which the degree is 8.315 times smaller, i.e., by the value of the universal gas constant \( R = 8.315 \text{ J/(K·mole)} \), then the equation of state of a substance becomes

\[
 pV = T, \tag{1} 
\]

where \( p \) is the pressure; \( V \) is the volume; \( T \) is the absolute temperature.

Since \( pV \) is the energy, then it follows from Eq. (1) that the temperature is also energy. The analysis of the mechanism of temperature-dependent processes allows considering it the energy of electromagnetic vibrations, more precisely, the electromagnetic field energy density.

The average value of the energy density of the vibrational motion of any medium \( U \) is expressed by the equation

\[
 U = 0.5\rho a^2v^2, \tag{2} 
\]

where \( \rho \) is the density of the medium; \( a \) and \( v \) are the amplitude and frequency of the vibrations.

For clarity, let us take a storm at sea as an example, i.e., the vibrational motion of the water. The wave height (amplitude of vibrations) and characteristic slope (frequency of vibrations) determine the force (intensity) of the storm, expressed in points, i.e., arbitrary units. The intensity of the vibrational process of an electromagnetic field is expressed in the same way in