Introduction

Modern development of the chemical industry and allied branches, in which new technological processes are designed alongside the intensification of those existent, imposes new requirements as to further development of the theory of heat and mass transfer and the accumulation of reference data without which engineering calculations are unfeasible.

Only a correct solution of the problems of heat and mass transfer of the substance in wet materials that are subjected to technological treatment will provide their high quality.

As a result of the investigations conducted by A. V. Luikov, it is established that mass transfer of the absorbed substance is determined by the form of its binding to the frame of a solid body. A different intensity of the energy of moisture binding to the material, alongside its structure that specifies the moisture and vapor motion inside the material, determined the kinetics of drying and moistening of materials.

The works of P. A. Rebinder, M. M. Dubinin, S. M. Lipatov, A. V. Dunamskii, Yu. L. Kavkazov, A. A. Rode, et al., have established basic principles of the binding of the absorbed substance to capillary-porous colloidal bodies and revealed properties of the bound moisture, i.e., have developed a modern theory of the forms of moisture binding to wet materials.

The moisture removal from the body involves a breaking of moisture binding to the body, on which a certain energy is spent. Therefore the forms of moisture binding should be classified by the principle of studying the intensity of binding energy.

By such a principle, P. A. Rebinder's scheme has been constructed that is taken as a basis in the current study.

Relying on P. A. Rebinder's theory, the study considers the forms of moisture binding to materials from the standpoint of the binding energy and uses the well-known assumptions that the chemical potential of mass transfer of the substance in wet materials is a factor of rate of the mass transfer processes.

Proceeding from fundamental concepts of the thermodynamics of irreversible processes and classical thermodynamics, expressions for the chemical potential of mass transfer for various kinds of binding are obtained in an explicit form, which makes it possible to determine the direction and limit of a spontaneous progress of the processes of mass transfer of the substance from one part of the system to another, since a spontaneous progress of the processes of interaction between different parts of the system is possible only in the direction of equalization of the factor of rate for all parts of the system. The attainment of the same values of this factor is the limit of a spontaneous progress of the process under these conditions and, therefore, is the equilibrium condition.

Extensive experimenal data for sorption and desorption isotherms were systematized and processed for calculating thermodynamic parameters and mass transfer coefficients in colloidal capillary-porous bodies.

It is known that thermodynamic parameters and mass transfer coefficients characterize the transfer rate and are the basis for calculating and controlling hydrothermal processes. They determine the ability of the material to absorb and release moisture in a hydrothermal process and account for the structural and mechanical changes occurred.

It is possible to present the following (incomplete) list of problem that cannot be solved without using thermodynamic parameters and mass transfer coefficients in colloidal capillary-porous bodies [141]: automatization of technological processes involving the hydrothermal treatment of nonmetallic materials, processing of experimental data on mass transfer in a dimensionless form, application of analytical solutions of heat and mass transfer to practical calculations, calculation of the quantity of mass that has passed from one body to another on their direct contact, design of thermal devices and apparatus associated with the kinetics of heat and mass transfer, analysis of the forms of moisture binding to the material, etc.

The foregoing demonstrates how important it is to have data on thermodynamic parameters and mass transfer coefficients for colloidal capillary-porous bodies. The accumulation of such data and their study is among the most important tasks of the science of heat and mass transfer.

The creation of an artificial climate is of special importance for the conducting of technological processes in such industries, where hygroscopic materials serve as a raw material to be treated. In these industries, the relative humidity and temperature of air in production areas determine the grade of products and therefore, the conducting of the technological process.

Thus, for example, air conditionings is needed in manufacturing fibers (especially man-made) at textile factories, in color printing in polygraphy, in storing leather at shoe factories, for providing a normal tableting process at pharmaceutical plants, in manufacturing and processing film in the film industry, at tobacco and tea factories, in producing cocoa powder and caramel at confectionary factories, at bread-baking plants, etc.

Regardless of the industry, optimum conditions for the best conducting of the technological process should be determined by technologists of a given production. The pinpointing of optimum conditions through experimental selection of combinations of the temperature and relative humidity of air in the area, which provide an appropriate specific moisture content of the treated material, is a fairly complicated problem.

This problem can be simplified using the value of the chemical potential of mass transfer of the substance in the hygroscopic region, whose gradient is exactly a driving force of mass transfer.

In the current study, such procedure is proposed for calculating optimum parameters of air for conditioning in production areas, public buildings (book depositories, archives, museums, etc.) and for storing hygroscopic materials in warehouse.

Having available data on the average specific isothermal mass capacity for various materials, which are presented in the study, it is possible to give recommendations for selecting individual components that enter into the system of contacting bodies or structures of wet materials and to choose the type and mode of the technological process with an objective of obtaining an optimum moisture-accumulating ability of the material, i.e., to produce the material with preset hygroscopic properties.