1 Properties of dried materials

1.1 Classification of wet materials

Dried materials constitute colloidal or capillary-porous bodies. The space occupied by the solid particles is termed the skeleton of the body. The liquid-gas mixture filling the pore space will be called the moisture.

Lots solids of natural or artificial origin have a porous structure. The dimensions of pores in wet materials are rather small, so the pores are not usually visible with the naked eye. In order to better visualize the geometrical structure of solids in general, and the porous bodies specially, we will quote some data on elementary particles and dimensions of pores. The radius of the atomic nucleus is of order \(10^{-15}\) m, while the radius of the hydrogen molecule has \(1.36 \times 10^{-10}\) m, that is the atomic nucleus is almost a hundred thousand times smaller than the hydrogen molecule.

The fundamental mass of a molecule is concentrated in the atomic nucleus: the proton mass is \(1.6724 \times 10^{-27}\) kg and the mass of the electron \(9.1066 \times 10^{-31}\) kg. The mass density of iron is \(\rho_{Fe} = 7.8 \times 10^{3}\) kg/m\(^3\), and the mass density of the iron nucleus \(\rho_{n,Fe} = 1.16 \times 10^{17}\) kg/m\(^3\). As \(\rho_{n,Fe} / \rho_{Fe} = 7.8 \times 10^{-14}\), then one can say that the bodies consist mainly of “voids” and only small spaces are occupied by matter. In spite of this, a body consisting of such molecules is considered in mechanics as a continuous body. These voids cannot be penetrated by liquid, and therefore such bodies cannot be termed as porous ones.

A body is said to be a porous one if its structure contains void spaces of dimensions exceeding the molecule radius, that is voids greater than \(0.5 \times 10^{-9}\) m. Porous bodies become wet when immersed in water, or are able to soak moisture from the ambient air, or they contain the moisture as a natural component, e.g. plants. Generally, porous bodies can be divided as follows:

- Colloidal bodies (elastic gels), which change their dimensions significantly during drying.
- Capillary-porous bodies, where the capillary forces reach greater values than the gravitational forces (which occurs in capillary radiiuses of order \(0.5 \times 10^{-9} \ m < r < 10^{-7}\) m, that is for micro-capillaries).
- Porous bodies, where the capillary forces are smaller than the gravitational forces (the pore dimensions or capillary radiiuses are grater than \(10^{-7}\) m and are called macro-pores or macro-capillaries).
It was stated experimentally (Lykov 1968), that macro-pores or macro-capillaries do not soak humidity from the ambient medium. On the other hand, a complete removal of the moisture from macro-capillaries is possible through drying.

The amount of humidity adsorbed by a porous body depends on the porosity (the fraction of voids to the total volume of the body) and on the specific internal area (the ratio of internal area in the pore space to bulk volume).

One states that the specific area of a porous body with micro-capillaries is greater than that of a porous body of the same volume with macro-capillaries. For the active carbon, for example, the specific internal area of micro-capillaries of radius \( r = 10^{-9}\)m is in the range from \(9 \times 10^5\) to \(15 \times 10^5\)m\(^2\)/kg, and that of macro-capillaries of radius \( r = 10^{-6}\)m reaches the values between 350 and 1700 m\(^2\)/kg.

The voids are termed capillaries if the meniscus of the liquid inside the capillary is formed mainly due to action of the surface tension and less by gravitational forces. For example, voids of a radius smaller than \(10^{-5}\)m can be considered as capillaries. The influence of gravitational forces on the liquid in such capillaries can be neglected and the error resulting from this neglect does not exceed 6%. Voids of a radius greater than \(10^{-5}\)m cannot be considered as capillaries and the action of gravitational forces on the pore liquid cannot be neglected.

From the point of view of moisture transport the most important pore structure parameter is the permeability or rather the specific permeability. It determines the ability of a porous body to percolation of fluid through the pore space and is a part of the moisture transport coefficient. The permeability concerns the interconnected pores. The non-interconnected pores do not give access to moisture transport. The dimension of the specific permeability is a length squared, which suggests that the natural permeability unit in SI system should be m\(^2\).

There are also other parameters describing the pore structure such as: size of pores, pore size distribution, grain size, and tortuosity. While the reader may feel intuitively what these notions mean, it is not easy to give for them precise geometrical definitions. They will be used less frequently in this book, and we shall not devote more time to them here. The reader interested in their exact definitions is referred to the literature, e.g. (Scheidegger 1957; Bear and Bachmat 1990; Coussy 1995).

### 1.2 Characterization of moisture bounding a solid skeleton

The moisture in pore space of a porous body usually constitutes a mixture of gas and water or water solution. The water is bounded with the solid particles through various forces. Generally, one differentiates the following bounds of the pore water with the porous solid (Lykov 1968; Kneule 1970; Ošcik 1982; Strumillo 1983):

- Chemical bounds (ion and molecular).
- Physical-chemical bounds (adsorptive, osmotic and structural).
- Physical-mechanical bounds (capillary and free).