дорожной одежды в режиме реального времени при строительстве автомобильной дороги. К сожалению, не всегда возможно добиться такого результата с помощью традиционных методов контроля соответствия выполненных дорожно-строительных работ. Применяя при строительстве и реконструкции дорожной одежды георадарно-лазерное сканирование, обеспечивается точный контроль толщины слоев дорожной одежды ее плотности, что положительно скажется на долговечности автомобильных дорог.

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Idealization of the form and packing of loose material particles to perform mathematical modeling

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Abstract

The frequency dependent conductivity and permittivity of loose materials are modelled using electrical networks consisting of resistors and capacitors. The electrical network consist a heterogeneous microstructure that contains insulating (the capaciting) materials, as well as conductive elements, such as the resistor. Fundamental the this model use is to, to obtain electrical properties of a loose materials consisting of particles of two different sizes. Results receieved in this article, allow to design moisture sensors for loose materials, calculate the mathematical model as well to increase the accuracy of their measurements

Keywords: heterogeneous microstructure; loose material; electrical network; moisture sensor

There is a need for an accurate measurement of the moisture content of heterogeneous loose materials regardless of the size of the particles contained. At the initial stage of development of such moisture meters it is expedient to perform mathematical modeling of the behavior of heterogeneous loose materials in the electric field of the sensor [1, 2].

Most mathematical loose material models have such a weak point as that they are not exactly able to obtain frequency and humidity properties of loose materials with varying particle sizes [3, 4, 5].

In general, a problem of modeling of electrical and physical properties of loose materials reduces to finding of integral values of the total electrical conductivity of a loose material sample. A structure consisting of two particles with different geometrical dimensions should be taken from the loose material sample in order to mathematically describe the whole sample. Such a structure is called the basic or elementary structure of the loose material. We assume that the whole volume of the loose material consists of such basic particles. Thus, properties of the whole volume of the loose material can be inferred when examining characteristics of an individual

particle. Since such characteristics are applied to an individual particle they are conventionally called as differential parameters.

Specific electrical resistance, specific conductivity, relative permittivity, microhardness, density, heat capacity and other parameters could be investigated. Parameters of the loose material investigated in the electric field of a capacitive sensor are relative permittivity ϵ or dielectric loss tangent $\text{tg}\delta$. Their volumes depend on loose material properties such as particle composition, particle nature, moisture content in the loose material and others [6].

We assume that the loose material under examination consists of two types of cube-shaped particles packed as shown in Figure 1.

Figure 1. Proposed variant of particle packing of the bulk material consisting of particles with two different sizes (each particle having its own nature)

Let us consider an idealized structure of the loose material packed in the manner shown in Figure 2 in one of the orthogonal planes.

Figure 2. Idealized loose material structure with cubic packing presented in one of the coordinate planes

In order to develop a mathematical model of the loose material we hypothesize the following facts:

- the loose material is heterogeneous and two-component;
- Particles 1 and 2 are respectively the first and the second cube-shaped components and have different sizes;
- the particle is evenly moistened;
- packing of particles in relation to each other and the electric field vector E is shown in Figure 2;
- there is some space between particles having the medium with its electrical and physical properties, and porosity of the loose material structure is determined by a ratio of geometrical dimensions of particles;
- surfaces of particles in the direction of the electric field vector are equipotential;

— current lines in particles are parallel to the electric field vector E and are equally distributed in particles.

The loose material structure in Figure 2 has two cube-shaped particles, where a and b are edge dimensions of such particles, wherein a and b are edge dimensions of such particles, wherein a and b are edge dimensions of such particles. Space between loose material particles is filled with certain medium. The loose material under examination is capillary-porous body. In order to receive differential parameters of the loose material we choose a section in the volume of the loose material, which consists of two particles and contact zones. Such a system consisting of two particles is shown in Figure 3.

Figure 3. System consisting of two particles

The Particle 2 is presented in the system as an entire cube with a edge. The Particle 1 is divided into two equal halves with b edge in the direction of the electric field vector E . Such representation of two particles system allows considering conductivity of particles and contact zones between particles. Change of a and b sizes results in change of the loose material particle composition.

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