Key performance indicators for the mining and transport equipment 3 experiments are shown in Figure 4. For the 2 models of excavators in the simulation model designed indicator volume of ore shipped and average fuel consumption per 1 ton of ore shipped. According to the results (Figure 4.A), due to the higher load capacity index of the volume of ore shipped excavator Busyrus RH-120 E to 25% more than the R-984 Liebherr C. However, diesel fuel consumption (Figure 4.C) 1 ton excavators both models are almost identical. Buying 1 excavator Busyrus RH -120 E will be more effective than the purchase of Liebherr R-984. For 3 models of trucks in the simulation model the average mileage figures were calculated and diesel consumption per 1 ton. According to the average range of CAT-777D 35% higher than CAT-AD60. Indicators show that theaverage mileage of Belaz dump trucks are the least in comparison with the above models. This is primarily due to the over-fitting model for dump trucks Belaz along the certain routes from the warehouse of the diamond ore to the mill, and from the quarry to the warehouse of the overburden. Buying trucks CAT -777D is more effective in reducing the cost of production of ore mining cycle due to lower the cost of diesel fuel and a higher load capacity.

As a result was developed simulation model in the Anylogic 7.2, which allows analyze and plan for mining in "Yubileyniy".

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# FRACTAL STRUCTURE COPPER CLUSTERS IN A MATRIX OF POLYTETRAFLUOROETHYLENE


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The object of research is indicated – composites based on polytetrafluoroethylene, obtained by using different forming technologies. The aim of this work is to study the spatial arrangement of particles of copper clusters in a matrix of polytetrafluoroethylene. For the quantitative description of the structure of fractal objects, fractal dimension is used. Fractal dimension can be one of the parameters that establishes the relationship between the structure of physical objects and their physical properties [1].

In the main part, an algorithm for recognizing copper clusters in a matrix of polytetrafluoroethylene a composite material from surface images obtained by optical microscopy has been developed]. The method is based on the threshold segmentation of clusters in accordance with the Otsu method [2]. The purpose of this method is to select a threshold that minimizes the ratio of the combined variance to the variance between the classes determined by dividing the histogram into thresholds. Based on the images obtained and the developed algorithm, the analysis and distribution of clusters in the matrix of polytetrafluoroethylene at mass concentrations of copper from 1 to 20% was carried out. In accordance with the ratio between the square of the perimeter of the fractal object and its area, the fractal dimensions of the profiles the filler clusters in the matrix are calculated. The fractal dimensions of the profile the selected segments the filler clusters in the polytetrafluoroethylene matrix increase from 1.65 to 1.72 when the mass concentration of copper varies from 1 to 20%. The filler forms clusters whose structure can be described within the framework of the modified diffusion limited aggregation model (RLA).

The determination of the geometric quantitative characteristics for describing the structure and distribution of the particles the filler clusters in the matrix the composite material is necessary for calculating the thermophysical characteristics composite materials, as well as strength calculations and the degree of modification.

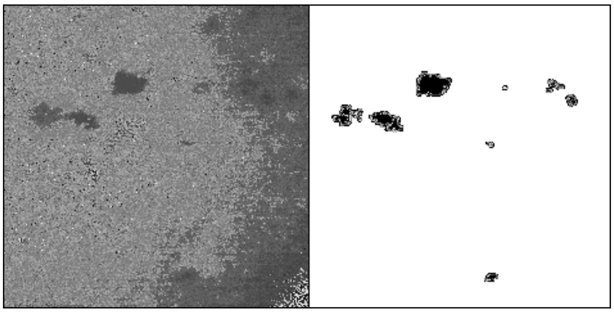

Figure 1 – Separation of copper clusters
(mass concentration 1%)

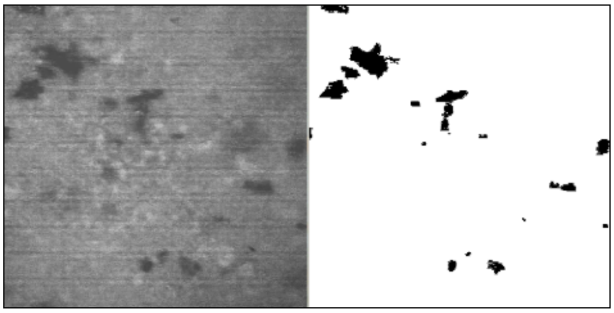

Figure 2 – Separation of copper clusters
(mass concentration 3%)

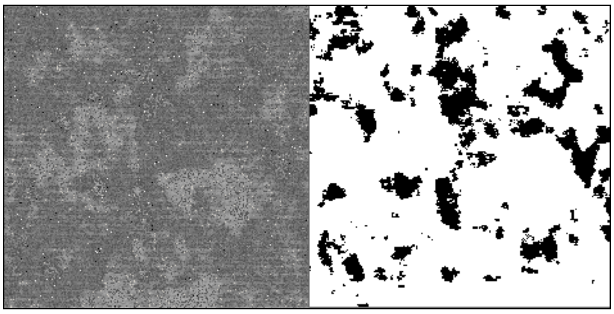

Figure 4 – Separation of copper clusters
(mass concentration 20%)

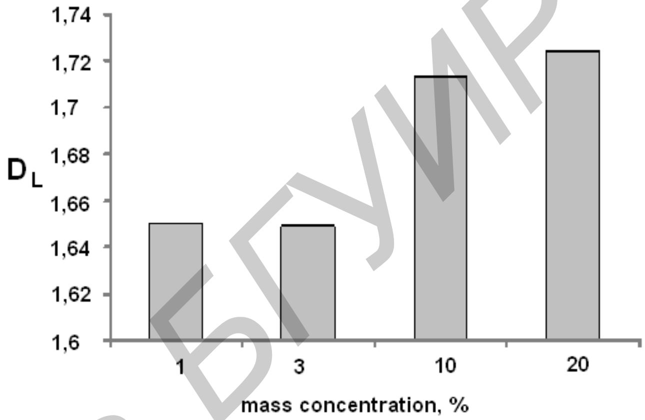


Figure 5 – Dependence of the fractal dimension of the profile of the filler clusters in the polytetrafluoroethylene matrix on the mass concentration of copper

**ACKNOWLEGMENTS**

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# NANO- AND MICRO- PARTICLES SYSTEMS: UNIQUE CHARACTERISTICS IN THE MULTIDIMENSIONAL SPACE OF OPTICAL PARAMETERS

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## I. INTRODUCTION

Three-dimensional disperse systems (3D DS) [1] – systems of nano- and / or microparticles (disperse phase) in a dispersive medium – are often called as dispersions, colloids, suspensions. One of the important tasks of fundamental 3D DS research is on-line monitoring of their condition. Optical data in combination with data of other methods can provide valuable information about processes within 3D DS (aggregation, sedimentation, flocculation, coalescence, fractal aggregation) and can help to create means for monitoring technological processes and the environment.

## II. MATERIALS AND METHODS

In our work [2-14], compatible non-destructive optical methods are used to characterize 3D DS: refractometry, absorption and fluorescence spectroscopy, light scattering (dynamic and static, integral and differential, unpolarized and polarized, single and multiple). By these methods, the following 3D water DS containing nano- and / or microparticles (with an average diameter from nanometers up to ten micrometers) were studied: proteins (serum albumins, egg albumin, lysozyme, chymotrypsin, chymotrypsinogen, hemoglobin), serum and blood plasma, nucleoproteins, lipoproteids, liposomes, influenza virus of different strains, fat emulsions, perfluorocarbon blood substitutes, antibiotics, polyaromatic hydrocarbons, synthetic polymers based on methyl sulfate homo-polymer, cyclodextrins, latexes of different sizes, liquid crystals, bacterial and other biological cells of different strains, shapes and sizes (E. coli, acidophilus rods, thrombocytes, thymocytes, lymphocytes, erythrocyte diagnosticums, etc.), metallic powders (iron hydroxides, ruthenium dioxide, colloidal silver), kaolin, kimberlites, fullerenes, zeolites, as well as various mixtures of: proteins and nucleic acids, proteins and polymers, liposomes with various substances (radiopaque agents, metal particles, enzymes, viruses, antibiotics), liquid crystals with surface active substances, mixture of E. coli cells with kaolin (water model), mixtures of anthracene with cyclodextrin, samples of oil, petroleum products, food products, samples of natural and tap water, air sediments in water, etc.

## III. RESULTS AND DISCUSSION

Three classes of parameters can be obtained from the different optical methods for nondestructive testing of 3D disperse systems with nano- and microparticles [2 – 4, 6]. As the result of our 3D DS research, the phenomenon has emerged that consists in the existence of unique characteristic for any of the studied 3D DS in the multidimensional space of the so-called "second class" optical parameters (obtained after processing experimental data without invoking any data about the particles of the dispersed phase). In other words, the characteristic of any 3D DS can be represented as a unique N-dimensional vector (a set of parameters of the second class) in the N-dimensional space of optical parameters. The N-dimensional vector of the system can reflect implicitly all its features: the structure and shape of the particles, the refractive index of the matter of particles, the distribution functions of the number and mass of particles in size, etc. The most informative parameters for a particular system can be used for on-line control sensors creation.

## IV. CONCLUSIONS

Most of the studied 3D DS contain nanoparticles (these can be debris of viruses or cells). As a rule, such mixed systems are not stable and under changing conditions tend to form even micron size aggregates (associates, agglomerates). In this regard, on-line monitoring the 3D DS state is of particular importance, for example, when using different batches of blood-substitutes or for obtaining information on the pathogenic viruses or bacteria in water.

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# SPATIAL EQUATIONS OF THE LINEAR KELVIN-VOIGT VISCOELASTICITY, BASED ON DEVIATORS


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## I. INTRODUCTION

The aim of this paper was the theoretically substantiate derivation of a complete spatial system of equations using deviators for one of the simplest models of creep-the Kelvin-Voigt model, for which one-dimensional differential equation is well known [1]. In addition, it was necessary to determine the constraints on the physical parameters under which the constructed spatial generalization can be used to solve three-dimensional creep problems of a rigid body.

In modern scientific literature, it was sometimes mentioned that this spatial model was used [2, 3]. However, the systems of equations of state cited in these works (by means of which some spatial applied problems were solved) indicate that the authors incorrectly interpret this model and, accordingly, use incorrect equations of state in solutions.

## II. ONE-DIMENSIONAL LINEAR MODELS OF KELVIN-VOIGT VISCOELASTICITY

By a one-dimensional linear viscoelastic Kelvin-Voigt model we mean the equation of state of an uniaxially loaded rod, which can be written in the form [1]:

$$\sigma(t)=E\cdot\varepsilon(t)+\eta\cdot\dot{\varepsilon}(t) \tag{1}$$

where $E$ is predetermined modulus of elasticity of the rod material, $\eta$ is predetermined viscosity of the material, $\sigma(t)$ is the priori given (control) average stress on the rod, $\varepsilon(t)$ is the required average rod deformation, $\dot{\varepsilon}(t)=\frac{d\varepsilon(t)}{dt}$. The expression "average over the rod" explains the absence of an axial coordinate in the recording of the equation of state (1). Equation (1) is also called the law of deformation of a non-relaxing body [1].

## III. SPATIAL GENERALIZATION OF THE LINEAR KELVIN-VOIGT MODELS WITH HELP OF DEVIATORS

It was considered a three-dimensional space with a Cartesian coordinate system $\mathbf{x}=(x_1,x_2,x_3)$. Let $D_\sigma(\mathbf{x},t)$ is deviator of stresses [4], $D_\varepsilon(\mathbf{x},t)$ is deviator of deformations [4], $G=\frac{E}{2\cdot(1+\nu)}$ is shear modulus, $\nu$ is Poisson ratio of a body material, $K=\frac{E}{3\cdot(1-2\cdot\nu)}$ is bulk modulus [4].