https://www.sworldjournal.com/index.php/swj/article/view/swj11-02-012
DOI: 10.30888/2663-5712.2022-11-02-012

УДК 632.935.4

ACTIVATION OF METALLIZED COLLOIDAL SOLUTIONS
АКТИВАЦІЯ МЕТАЛІЗОВАННИХ КОЛОЇДНИХ РОЗЧИНІВ

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Анотація. *Одним з найважливіших чинників стабілізації є гідродинамічний опір витісненню рідкого дисперсійного середовища з прошарку між частинками, що зближуються. Враховуючи його неоднорідність (гетерогенність), досить складно спрогнозувати вплив в'язкісних властивостей на таку гідродинамічну характеристику. Непрямою характеристикою кінетичної стійкості металізованої фарби як колоїдної системи є її схильність до седиментації.*

На початку полімеризації рідка металізована система поступово перетворюється на гель і частково втрачає агрегатну стійкість, але зберігає кінетичну або тимчасову седиментаційну. Вплив сил на седиментаційну стійкість системи залежить від кількості та дисперсності частинок металевого наповнювача. Седиментаційна стійкість металізованої колоїдної системи пов'язана опосередковано з умовами для активації такої системи зовнішніми коливаннями. Тому виникає актуальна задача аналізу прогнозованої поведінки металевих частинок при акустичній обробці дисперсійного середовища.

Ключові слова*: седиментація, ультразвукові коливання, металізована колоїдна система, гідродинамічна сила.*

Introduction

It is known that at relatively long distances (30...50 microns) between the composites of the dispersed phase, the convergence of particles occurs due to inertia of them, gravitational forces [1]. When distance decreases, the molecular forces of interaction are manifested. The movement of filler particles in the bidisperse system (which is metallized colloidal) is determined mainly by the action of inertial forces that occur at the beginning of curvature of the lines of flow of liquid flowing over the nude of dispersed particles. According to modern research, at a distance of 10... 20 microns between them, sedimentation begins to interfere with the hydrodynamic take on mode, caused by the withering resistance of the layers of liquid. However, at such distances, particles can converge due to the action of hydrodynamic force, which cannot provide direct contact between the components due to the increasing resistance of the layers of the dispersed phase.

The purpose of the work

The presented scientific study aims to substantiate the mechanism of acoustic cleaning of metal particles in colloidal systems of printing purposes.

Results of the conducted researches

When a fine electromagnetic filler is injected into the composition, the force of magnetic interaction occurs, which, creating an electromagnetic barrier,contributes to the uniform distribution of the magnetic filler in the composition volume.

Consequently, the total force acting on a dispersed particle that is approached in the process of sedimentation to the printed surface is generally equal to:

$$F=F_t+F_m+F_u+F_e \tag{1}$$

where F_t is the gravity of a small particle; F_m – the force of intermolecular inter action, F_u - the force of hydrodynamic interaction, F_e - the force of electromagnetic interaction.

When forming the frame of the spatial grid of the filler, in the layers of which the polymer matrix is placed, the processing of positions filled with polymer compositions by the electromagnetic field allows increasing the aggregative and sedimentation stability of the systems and getting protective polymer-compositional coverings with a sufficiently uniform distribution of the filler.

In the process of sedimentation and filling (in the case of non poping pigments) the flows of micro inequalities of the material with the applied printing ink, fine particles, including metal ones, form coagulants, the area of contact of which with the surface of the transition layer of the printed material exceeds the contact area of the initial particles. Coagulant formed from small fractions of powder on the micro inequalities of the surface of a sufficiently dense substrate, which provide adhesion stability of the coating due to Van Der Waals interaction.

Printing coating in most cases is a paint film based on filled polymers, the structure of which was due to the gradual transformation of liquid-shaped binding into a solid composite compound [2]. The kinetics of this transformation is determined by the range of physical and chemical parameters: suction rate and evaporation of the solvent; gradient of its concentration in local surface zones of printing materials; the presence of foreign inclusions in the form of micro droplets of water and other impurities.

Activation of metallized colloidal solutions by ultrasonic vibrations in real conditions and the rate of consolidation and deposition of particles suspended in a liquid medium are affected by the intensity and time of ultrasonic exposure, as well as the parameters of the processed technological volume. To achieve the maximum possible intensity of the particle coagulation process during the sonication of the metallized colloidal solution, it is necessary to optimize the intensity or time of ultrasonic exposure.

Metallized colloidal solutions for printing purposes can be used as model systems to identify patterns of influence the polymers on a hard surface. There is a need for research aimed at identifying the optimal modes of ultrasonic influence under the condition of achieving maximum stabilization and homogenization of metallized colloid solutions by simultaneously grinding large plastic granules into smaller ones and coagulating into a relatively equilibrium dispersed phase in the form of plasticized ball-like particles.

The mechanism of acoustic coagulation is associated with the action on particles of hydrodynamic forces - the forces of Bernoulli and the forces of Bierknes. However, expressions for these forces are obtained for the case of hydrodynamic action of particles in a homogeneous flow of ideal incommunicable liquid, at the same time, as in the spread of sound waves, the flow of liquid is significantly heterogeneous and non-stationary.

When studying the hydrodynamic interaction of particles in a liquid, different problem statements are possible. This is due to the possible simplifications of the equations of the hydrodynamics, which are non lineable in terms of variable values. [3]. There are many works in the literature devoted to the problem of particle interaction in the flow of viscous insecurable liquid in Reynolds' small numbers. Fluid motion equations are greatly simplified and become linear Stokes equations. At high frequencies, non-stationary terms in motion equations become the main ones.

It is known, that the distribution of the pressure velocity around two particles of one coaxial radius located in the stream of incurable liquid, the speed of which **U** at infinity is a time-dependent linear coordinate function

$$U_i(t)=U0_i(t)+E_{ij}(t)\,x_j \qquad (2)$$

Moreover, the E_{ij} tenor meets the conditions

$$E_{ij}=0,\ E_{ij}=E_{ji}$$

The analytical solution to the problem of interaction of two particles in an ideal non-bearing liquid allows direct calculations of the forces of $\mathbf{F^A}$ and $\mathbf{F^B}$ acting on spheres **A** and **V** from the liquid side [4]. Force is calculated as

$$F_i^A = \oint(p\delta + \rho(U_i+u_i)\,(U_j+u_j)\,n_j\,A ds\ , \qquad (3)$$

where p-pressure ,u- perturbation of speed, ρ – fluid density. The integral is taken on the S^A surface of particle A, the external normal to which is the vector nA. P pressure equals

$$p=-\rho\ \partial\varphi/\partial t-\rho\ (U_j+u_j)/2 \qquad (4)$$

The obtained expressions for the forces $\mathbf{F^A}$ and $\mathbf{F^B}$, acting on particles **A** and **B** in an ideal insensitive liquid, allow to determine the speed of movement of particles acquired by them as a result of interaction with the flow of liquid with each other and to investigate the dynamics of their movement. Using Newton's second law, we obtain a system of differential equations. Due to the complexity of expressions for forces acting on particles, the system of equations was solved quantitatively. The graphs below show the results of calculations for the case when the density of particles is less than the density of the liquid at the position oriented along and across the flow rate of the running liquid (Fig.1).

The results of quantitative modeling show that it is possible both the convergence of particles and their distance from each other. In addition, if the rate of the infused flow of unsecured liquid is directed at an angle close to the straight, relative to the line connecting the centers of spheres, then the particles converge (Fig.2) under the action of the result of Bernoulli force. When positioning spheres along the speed and they are removed from each other.

Consider now two particles that are located in a stream of ideal compressive fluid : $\mathbf{E_{ii} = 0,\ E_{ij}=E_{ij}}$

The distribution of velocity and pressure around particles is described by the equations of insurable liquid. However, if the characteristic size of λ current, on which there is a change in the values in the liquid due to compressivity, satisfies the condition **λ>>r**, where **r** is the distance between the particles, then near the particles of the equation for speed and pressure can be written in the form of analogical for incompressible liquid. The only difference lies in the condition $\mathbf{E_{ii}=0}$. This is easily taken into account by additional terms in the expression for potential.

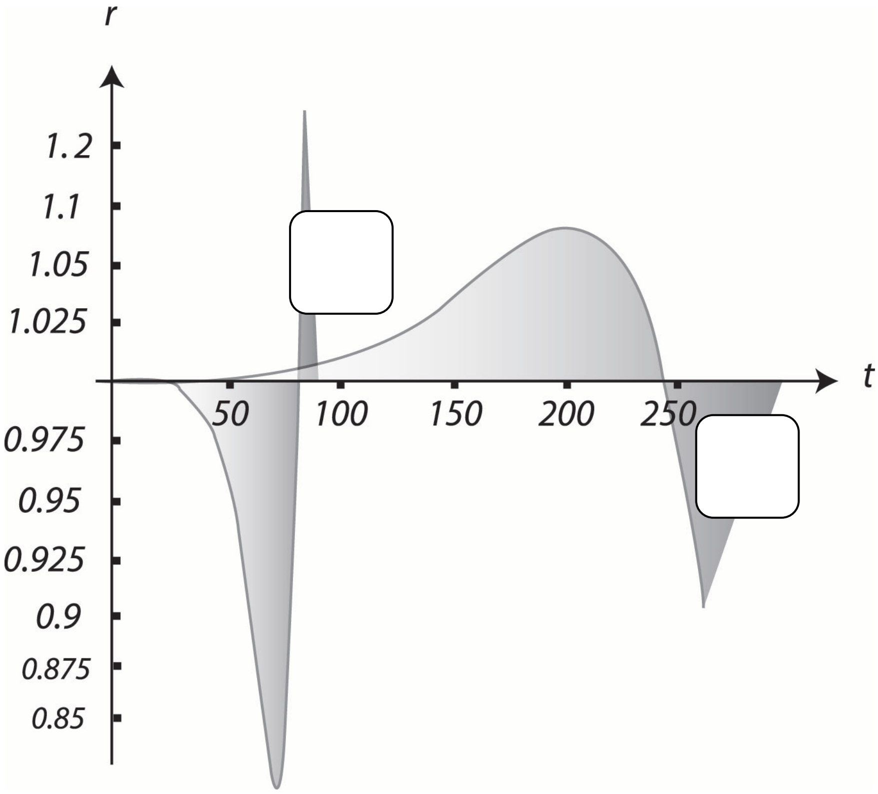

Fig.1. Results of calculations for the case of particle orientation along (1) and across (2) of the stream

Using the expression for the potential of fluid velocity around two particles in an ideal compressed liquid, we find expressions for the forces $\mathbf{F}^{\mathbf{A}}$ and $\mathbf{F}^{\mathbf{B}}$ acting on spheres **A** and **B** on the fluid side and making up the differential equations of particle movement. The equations are solved quantitatively. The results of calculations are given below in the graphs for the case when the density of particles is less than the density of the liquid and the vector connecting the centers of particles, oriented along or across the speed of the flow of liquid (Fig. 2).

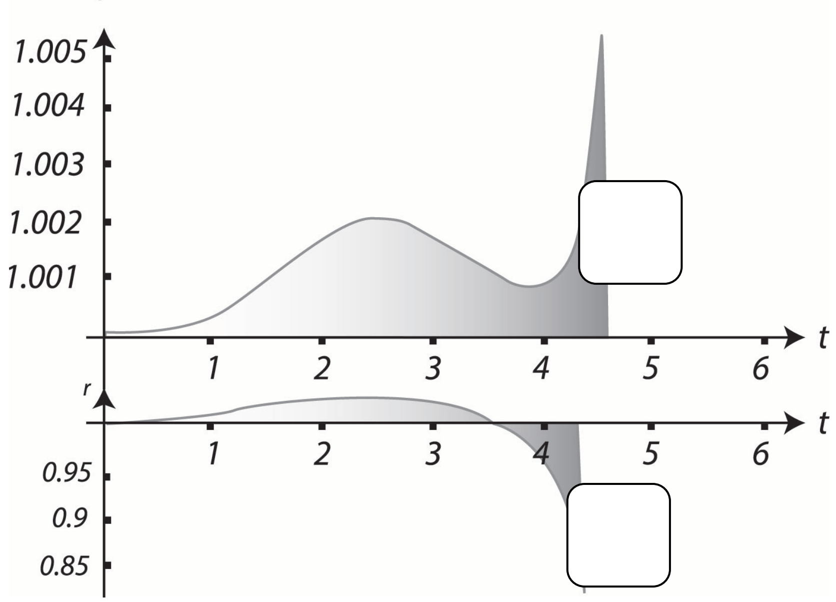

Fig.2. Calculation results for particle positioning along (1)and across (2) streams.

Fluid compressivity significantly affects the movement of particles in the sound wave. Unlike the case of the interaction of particles in the stream of incurable liquid, the union of particles is possible in the case when they are one after another relative to the direction of wave propagation (Fig.1). When particles are located across the wave, they are removed from each other (Fig.2).

The results of quantitative modeling show that it is possible both the convergence of particles and their distance from each other. In addition, if the flow rate of the insidious liquid that runs is directed at an angle close to the straight, relative to the line connecting the centers of spheres, then the particles converge (Fig.4.2)under the action of the result of Bernoulli force [5] .When the spheres are positioned along the speed, they are removed from each other.

The obtained results indicate that the mechanism of particle coagulation in the sound wave is qualitatively different from what the Bernoulli force gives in the flow of incurable liquid.

In real conditions, during sonication, the intensity and time of ultrasonication, as well as the parameters of the processed technological volume, affect the rate of consolidation and deposition of particles suspended in the liquid medium. To achieve the maximum possible intensity of the particle coagulation process during the sonication of the metallized colloidal solution, it is necessary to optimize the intensity or time of ultrasonic exposure [6].

The energy of the ultrasonic wave absorbed in the defective zones of the crystal lattice of shaving particles is consumed to relieve local stresses, unlock dislocations, increase their mobility, which provides a more intensive course of cleaning of metal pigments.

The obtained experimental results allowed to analyze the processes that occur in metallized colloidal solutions under acoustic influence of varying intensity. To implement the process of intensive coagulation in a small technological volume, 25% of the power and time of influence of the order of 2 minutes is enough. With an increase in exposure time, there is a slight deterioration in the coagulation process, which indicates that at low power the process is more efficient, but a small volume and a greater amount of radiation intensity in it lead to the gradual cavitational destruction of the increased particles.

Conclutions

To implement the process of intensive coagulation in a small technological volume, 25% of the power and time of influence of about 2 minutes is enough. With an increase in exposure time, there is a slight deterioration in the coagulation process, which indicates that at low power the process is more efficient, but a small volume and a greater amount of radiation intensity in it lead to the gradual cavitational destruction of the increased particles. The conducted studies confirmed the effectiveness of the use of intensive sonication to accelerate the process of homogenization of metallized colloidal solutions.

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Abstract. *One of the most important factors in stabilization is the hydrodynamic resistance to displace the liquid dispersion medium from the layer between the convergence particles. Given its heterogeneity, it's quite difficult to predict the effect of viscosity properties on such a hydrodynamic characteristic. An indirect characteristic of the kinetic stability of metallized paint as a colloidal system is its tendency to sedimentation.*

At the beginning of polymerization, the liquid metallized system gradually turns into a gel and partially loses aggregate stability, but retains kinetic or temporary sedimentation. The effect of forces on the sedimentation stability of the system depends on the number and dispersion of metal filler particles. The sedimentation stability of the metallized colloidal system is indirectly related to the conditions for activating such a system by external oscillations. Therefore, there is an urgent task of analyzing the predicted behavior of metal particles in the acoustic processing of the dispersion medium.

Kay words: *sedimentation, ultrasonic vibrations, metallized colloid on system, hydrodynamic force.*