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# ANALYSIS OF FACTORS AFFECTING THE SIZE OF WATER DROPLETS IN THE EMULSION

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*It is proposed to utilize oil-containing waste by preparing emulsions based on them and then using it as an anti-adhesion coating of the working surfaces of molds to produce reinforced concrete products or additives to the main fuel for boiler houses. The following things were analyzed: the influence of the size of an intact drop of water in the emulsion, the wavelength, the dimensionless wave number, the surface tension, the average flow velocity of liquids, and the density of media on the stability of the emulsion obtained by shock waves arising from the operation of a pneumatic radiator.*

**Introduction.** About 100 thousand tons of automobile and industrial oils are consumed annually in the Republic of Belarus. The amount of waste generated from the using of oils is 80-85% of their original volume. Annually the enterprises of the country collect and process (without incineration) only 8,300 tons of used oils, which is less than 10% of consumption [1]. Meanwhile, the world collection of used oils is 15 million tons / year (about 50% of fresh production). That is, the Republic of Belarus currently lags far behind the most industrialized countries. Although, in Western Europe about 1.2-1.4 million tons / year of oils can either be illegally burned, or simply drained into the environment [2].

The accumulation of various oil-containing waste (OCW) in enterprises, including the chemical industry, is explained by the requirements that are imposed on spent oil products intended for regeneration, purification and use in exchange or along with other petroleum products. So, according to GOST 21046-86 mixtures of used oil products intended for use as a component of boiler fuel, should have a mass fraction of mechanical impurities not more than 1%, mass fraction of water not more than 2%, in addition, they should be free from contamination. To meet the requirements of GOST, it is necessary to have expensive specialized equipment at the enterprise. This in turn, combined with high transport costs for centralized reception points for most enterprises makes collection, recovery and utilization economically impractical.

For such enterprises, it is promising to find ways of using oil-containing waste directly at the enterprise or at the enterprises of the region, preferably with minimal expenses for cleaning and processing. Therefore, it is advisable to use OCW to prepare such commodity products, for which a high degree of purification from mechanical impurities is not required, and the presence of water in the OCW is more a positive property than a negative one.

One of the possible ways of such application is the production of emulsions and emulsols based on OCW with the help of shock waves arising from the operation of a pneumatic radiator. Such studies are conducted at the Polotsk State University [3-5]. Utilization of waste involves conversion into non-hazardous compounds by emulsification and the use of emulsions obtained both as anti-adhesion coatings of the mold surfaces for the production of reinforced concrete products and as an additive to the fuel of the boiler units. The first direction will allow refusing additionally from the use of expensive industrial emulsols and lubricants, and the second - to reduce the volume of nitrogen oxides and carbon emissions with flue gases into the atmosphere due to the controlled change in the combustion process of fuel [6-8]. A serious problem for the application of this method is the preparation of an emulsion with the required stability.

**Task formulation is to** investigate the factors influencing the stability of the emulsion.

**Results and discussion**. The stability of the emulsion (the ability to maintain its original properties over the entire volume over time) is determined by the volume of the released non-emulsified substance in percent of the total volume of the emulsion [9]. The stability of the emulsion is affected by its concentration, particle size and viscosity. The sedimentation rate of water droplets v in the emulsion is expressed by the Stokes formula

$$v = \frac{2(\rho_2 - \rho_1) r^2 g}{9\eta}, \quad (1)$$

where $\rho_2$ – density of water, kg / m$^3$;

$\rho_1$ – OCW density, kg / m$^3$;

$r$ – radius of a drop of water, μm;

*g* – gravitational acceleration, m / s$^2$;

η – emulsion viscosity, Pa · s.

Dependence (1) shows that the droplet sedimentation rate is proportional to the square of its radius. The smaller the droplet radius, the greater the stability of the emulsion. Stability increases with the viscosity of the liquid and the friction force of the droplet shift in the emulsion. On the other hand, the stability of the emulsion is affected by the number of possible recombinations, i.e. fusion of small droplets of liquid into larger ones.

Figure 1 shows the dependence of emulsion stability on the density of OCW $\rho_1$ and the size of water droplets *r* in the emulsion. It is seen that with increasing emulsion density and simultaneous decrease in the size of water droplets in the emulsion, the stability of the emulsion increases. We can not influence the density of the OCW of the site for disassembly and cleaning of equipment, but the size of the water droplets in the emulsion can be affected.

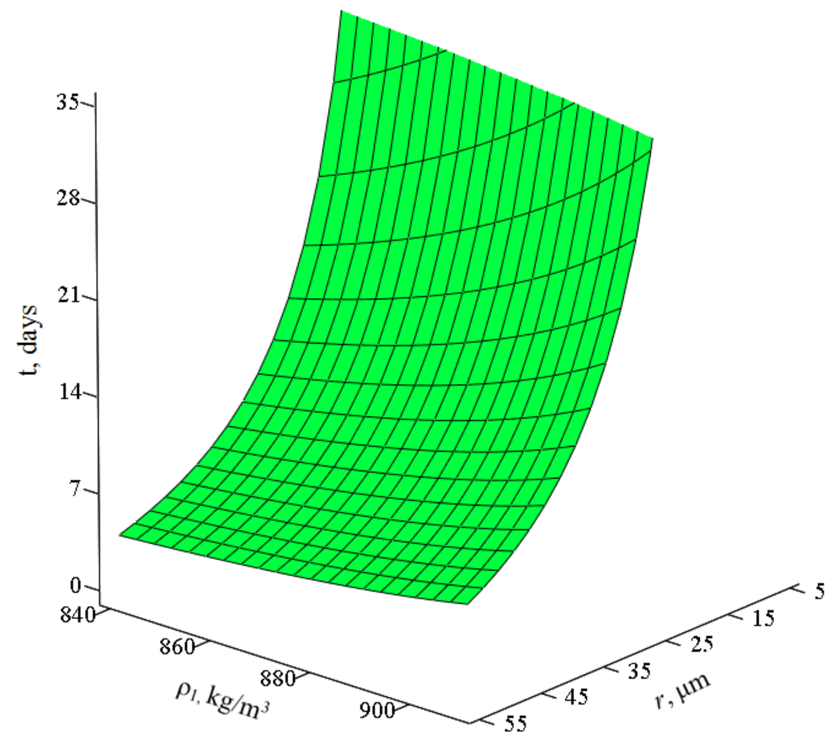


Fig. 1. Dependence of emulsion stability on density of oily wastes $\rho_1$ and size of water droplets in emulsion

The decay process depends on the viscosity, density and surface tension of the liquid, as well as the flow velocity and the amplitude of its pulsation. The influence of the driving force dramatically speeds up the process. The destruction of the interface occurs mainly at high fluid velocities in the turbulent flow regime. Generating shock-wave processes in a container with liquids by a pneumatic radiator, one can achieve an increase in the instability of the interface and its destruction. In the volume of the liquid, in addition to the wave phenomena near the shock-wave radiator, cavitation processes will arise with the formation of air cavities in the liquid, followed by their rapid slamming [10].

A droplet of radius $r = \lambda / 4$ opens from the surface of the liquid with a wavelength λ, and after the detachment of the drop, waves with an amplitude $\lambda / 8$ remain at the interface. These waves are initial perturbations for the subsequent detachment of droplets. That is, a decrease in the wavelength leads to a decrease in the size of the water droplets in the emulsion, and consequently to an increase in the stability of the water-in-oil emulsion made on the basis of oily waste [10].

Figure 2 shows the wavelength dependence of the emulsion preparation from the surface tension and the dimensionless wave number. Analysis of the results allows us to state that with a decrease in surface tension and a simultaneous decrease in the dimensionless wave number, the wavelength, and therefore the size of the water droplets in the emulsion, decreases, which leads to an increase in the stability of the emulsion.

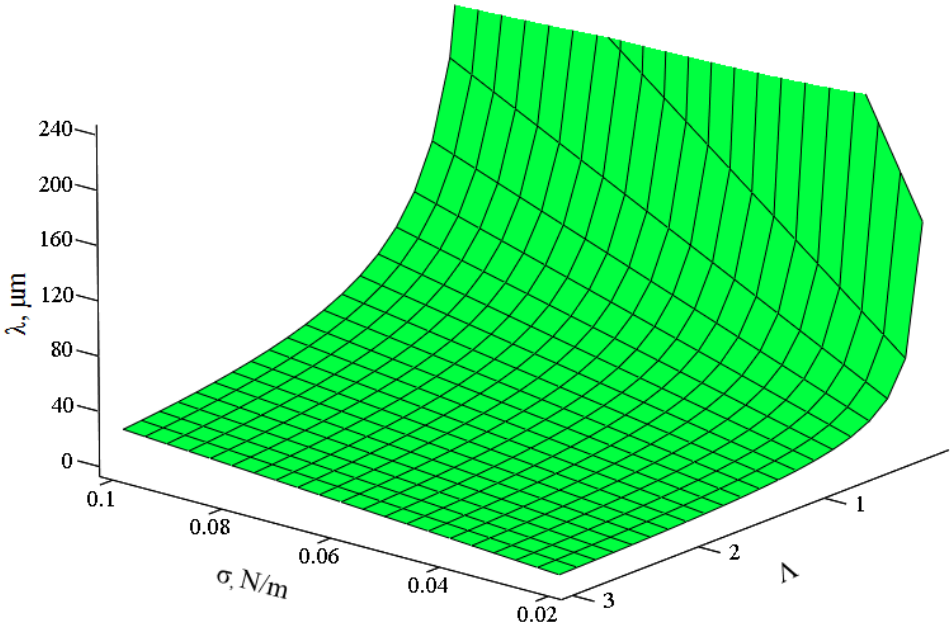


Fig. 2. Dependence of the wavelength λ from the emulsion
on the surface tension σ and the dimensionless wave number Λ

Figure 3 shows the dependence of the wavelength dimension in the preparation of the emulsion on the average flow velocity of liquids and surface tension. It is established that an increase in the flow rate of liquids with a simultaneous decrease in the surface tension leads to a decrease in the size of the water droplets in the emulsion.

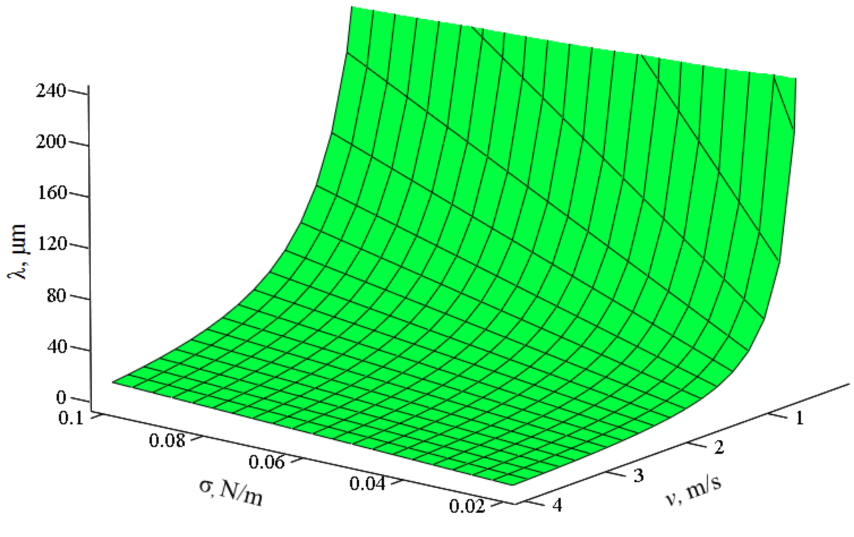


Fig. 3. Dependence of the size of the wavelength from the emulsion
on the average flow velocity of liquids and surface tension

Figure 4 shows the dependence of the wavelength dimension when preparing the emulsion from the density of OCW and the average flow velocity of liquids. Analysis of the results of calculations allows us to state that with a simultaneous increase in the density of OCW and the flow rate of liquids, the size of the water droplets in the emulsion decreases.

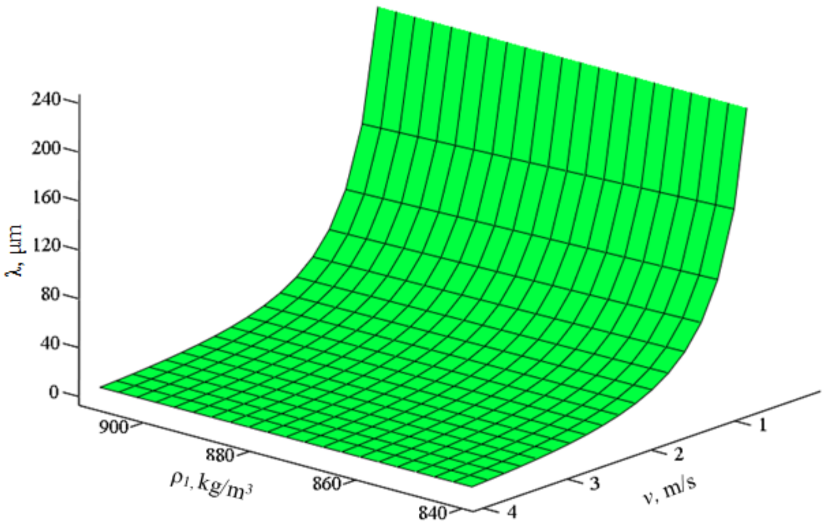


Fig. 4. Dependence of the size of the wavelength from the emulsion
on the density of OCW $\rho_1$ and the average flow velocity of liquids v

**Conclusion.** The established dependences of the wavelength and size of the undisturbed droplet in the emulsion on the parameters of the dimensionless wave number Λ, surface tension σ, average fluid flow velocity *v*, and $\rho_1$ and $\rho_2$ media densities make it possible to significantly reduce the amount of experimental studies to obtain an emulsion based on waste oil containing products with a predetermined stability.

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