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Research paper

Influence of Particle Size Distribution of the Filtering Loading on the Size of Particles of A Disperse Phase of an Emulsion

Dinar D. Fazullin, Gennady V. Mavrin

Kazan Federal University
**Corresponding author E-mail: denr3@yandex.ru,*
Tel. +79270491109

Abstract

Oil emulsions are formed in the course of oil production, transportation, storage and a wash of oil tanks. Some oil emulsions are highly dispersed and rather stable for division by methods of upholding, centrifugation and flotation. In work for effective division of an oil model emulsion the method of a contact coalescention received the filtering loadings from a granular and porous polytetrafluoroethylene (PTFE). Speed of filtration of a model oil emulsion through the filtering loading depending on the size of granules of PTFE is determined. Extent of division of an emulsion at filtration through loading with a size of granules of 0,5 mm of high, 89% for porous and 74,4% for granular PTFE, but with increase in the size of granules of the filtering loading extent of division of an emulsion decreases. The initial model emulsion is polydisperse system with sizes of particles of 567 - 3315 nanometers. After filtration through PTFE granules the size of particles of a disperse phase decreases, particles of oil coalesce and are late in a time, in a surface and space between granules. It is confirmed by formation of oil slicks on the surface of the filtering loading. And the size of granules of the filtering loading is less; the size of particles in an emulsion filtrate is less. By results of a research influence of particle size distribution of the filtering loading on the size of particles of a disperse phase of a filtrate of an emulsion is defined.

Keywords Oil emulsion, coalescence, coalescing filter, particle size, zeta potential, polytetrafluoroethylene, filter loading, and granules

1. Introduction

Oil-containing sewage is formed on oil fields in the course of extraction, preparation and transportation of oil, at a car wash, from cooling of processing equipment at machine-building enterprises, in tanks storages of fuel oil, etc. Sewage the containing oil products can be the free, emulsified and dissolved state. For division of emulsions use methods of a coalescention, flotation, coagulation, filtration, upholding, etc. Emulsions like "oil in water" with a size of particles of a disperse phase less than 100 microns are difficult divided. Coalescent filtration is emulsions, economic and effective for division. Productivity of a coalescention depends on the speed of a stream, depth of a layer, properties of a surface of material and the size of particles of a disperse phase of an emulsion. The surface area of the filtering loading directly influences efficiency.

The contact coalescention in granular material will be actually a combination of the interdrop coalescention intensified thanks to passing of a stream through material, and actually coalescention of drops with participation of the third phase - loading grains. Mechanisms of a coalescention of drops of oil products can be classified on two main groups: transport mechanisms and mechanisms of an attraction [1, 2]. Transport mechanisms include: effect of a current, sedimentation, inertia, diffusion, hydrodynamic forces of the movement. Mechanisms of an attraction include forces of electrostatic interaction, Van der Waals's forces, adhesions and forces of mutual adsorption.

In works [3-12] investigated office of particles of oil products from a firm surface under the influence of pressure (figure 1). Drops are affected by forces of adhesion and hydrodynamic forces. Hydrodynamic forces consist of two components, horizontal and vertical. The horizontal component is forces acting parallel to a surface on which colloidal particles while a vertical component is carrying power are located. Usually

the intensity of a horizontal component is more, than carrying power. The horizontal component has significant effect on the moment when the particle of a drop separates from a firm surface. Rotation and shift of drops appears because of influence torque force.

It is possible to allocate the following conditions influencing process of a coalescention of particles of oil products:

1. The size of particles of a disperse phase - a particle of oil, oils, oil products.
2. Curvature of a surface of the coalescing loading.
3. Difference of density of a disperse phase and dispersive environment.
4. Temperature of the purified liquid exerts impact on density, viscosity and an interphase tension.
5. Vibration speeds up the number of collisions of drops and also has the stabilizing effect on an emulsion [13].

Modeling of filtration of an emulsion like "oil in water" through the coalescing filter is studied in work [14] with use of a trellised method of Boltzmann (LBM). The numerical imitating model for the coalescing phenomena based on LBM of free energy is developed. Modeling showed that filters with a big size of a time allow forming big droplets of a disperse phase, but coalescent drops do not detain. Authors developed the two-layer filters consisting of the finely porous filter for capture of drops and the coarse pored filter for increase in the size of drops for the solution of this problem.

Materials for the coalescing loading can be divided into porous materials, fibrous materials and the granulated materials. As the filtering loadings apply [15,16]: sand with a size of particles of 1,5-4 mm, polyethylene, polytetrafluoroethylene, polyvinylchloride, polypropylene granules of 0,5-5 mm in size, glass, polymeric, silicone balls, glass wool, crushed stone, the crushed rubber, foam rubber granulated basalt fiber, wood fibers, a rubber crumb, etc.

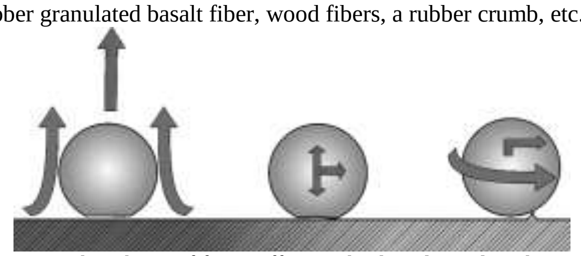

Figure 1:. The scheme of forces affecting the drop, located on the surface of a solid.

For realization of process of a contact coalescention of an emulsion like "oil in water" the material meeting the following requirements is necessary:
1) The water-repellency of a surface of the filtering loading - intensive interaction, a strong mutual attraction of molecules of a body and the liquid contacting to it.
2) The granulated structure, for ensuring low hydraulic resistance. Besides compliance of diameter of granules to the size of drops provides good adhesion. Material of the coalescing nozzle has to be regenerated continuously for ensuring continuity of process.
On the basis of the formulated requirements perspective is polytetrafluoroethylene (PTFE). In work as the filtering loading granules of porous and granular PTFE are considered.
The work purpose determination of dependence of extent of division of an emulsion and the size of particles of a disperse phase of filtrates of emulsion "oil in water" from particle size distribution of the filtering loading from PTFE.

2. Methods

In work carried out division of stable oil emulsions by a coalescention method by means of the filtering loadings from the granular and granulated porous PTFE. Granular PTFE was received crushing of sheet PTFE of the ftoroplast-4 brand, after crushing by means of laboratory sit, grains distributed on particle size distribution on particles: <0,5, 0,5-1, 1-2, 2-3 mm. Porous PTFE was received agglomeration of the powder PTFE of the F-4PN brand with a size of particles of 20 microns, at a temperature of 380 °C within 2 hours. After agglomeration of PTFE crushed by means of a mill and with the help sit divided into granules with a size from 0,5 to 3 mm.
The emulsion was received dispergating of oil of carbonic adjournment in 15% solution of the dodecyl sulfate of sodium. Dispergating was carried out in the mixing installation, the speed of rotation of the mixer made 3000 rpm, time of hashing of 15 minutes. Division of a model oil emulsion was carried out on laboratory filtrational installation. Through columns PTFE filled with granules and grains of different fractions (from 0,5 to 3 mm) with the set expense passed emulsions. Filtering of emulsions through a layer of granular loading happens in two stages: delivery of particles of oil to grains of loading and their sticking to a surface. A working zone when filtering is the surface of material and space between loading grains. And when using as loading of the granulated porous PTFE particles of oil will be, is late in a polymer time. Height of a layer of grains of polymer is 100 mm in a column with an internal diameter of 10 mm, 150 mm long, the mass of the coalescing filler was 2 grams. Concentration of oil products in a model oil emulsion made 86,2 mg/dm3.
The scheme of laboratory installation of filtration of an emulsion is submitted in the figure 2. The initial emulsion moves on a column with the filtering loading. Under the influence of gravity there is a filtration of an emulsion through polymeric loading, the filtrate gathers in a flask.

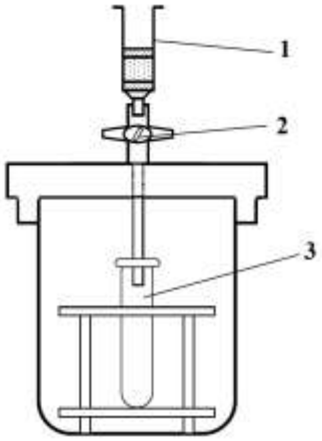

Figure 2:. Diagram of a laboratory filtration installation: 1 - column with filter loading (PTFE); 2 - crane; 3 - flask for collection of filtrate;

Regeneration of the filtering loading was carried out by washing with four-chloride carbon.
The size of particles of a disperse phase of model emulsions and their filtrates, determined by the analyzer of Nano Brook Omni brand [17, 18].

3. Results and Discussion

Results of measurements of the size of particles and ζ-potential of a disperse phase model oil emulsions are presented in the figure 3 and in table 1.

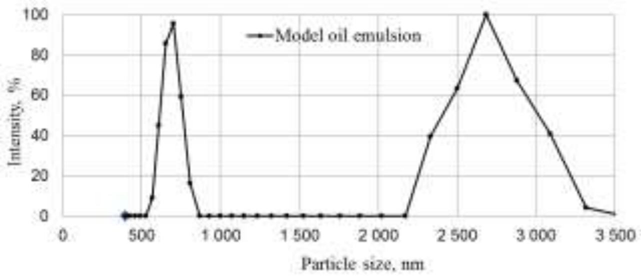

Figure 3:. Graphs of particle size distribution of a dispersed phase of model oil emulsions.

Table 1:. The values of the particle size and the z potential of the dispersed phase of the model oil emulsion

Emulsion	Particle size, nm	ζ-potential, mV
Model oil emulsion	567-807; 2329-3315	-30±3

On the basis of the data submitted in the figure 3 the emulsion to Inca is polydisperse system with sizes of particles of 567 - 3315 nanometers. On absolute value of ζ-potential the emulsion is stable. The less absolute value of ζ-potential of an emulsion, the stronger particles stick together, integrated.
The dependence of speed of filtration through a column from particle size distribution of the filtering loading is presented in the figure 4.

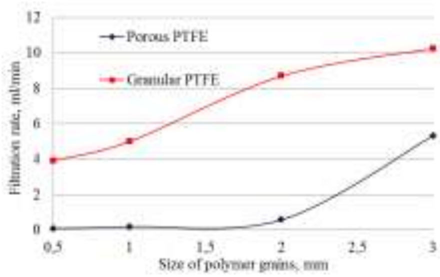

Figure 4:. Graphs of dependence of the oil emulsion filtration rate on the granulometric composition of the filtering charge with porous and granular PTFE.

With increase in the size of granules of the filtering loading the speed of filtration increases. At increase in the size of granules of porous PTFE from 0,5 mm the speed of filtration increases to 2 mm much, and at the size of granules of 3 mm the speed of filtration increases to 50 times. Filtration speed through granular PTFE at increase in the size of grains from 0,5 to 3 mm increases by 2,6 times.
After division of an oil emulsion into surfaces of granules oil slicks, result of a coalescention and aggregation of particles of oil were formed (fig. 5.). With reduction of the size of granules of the filtering loading the area of an oil slick increases.

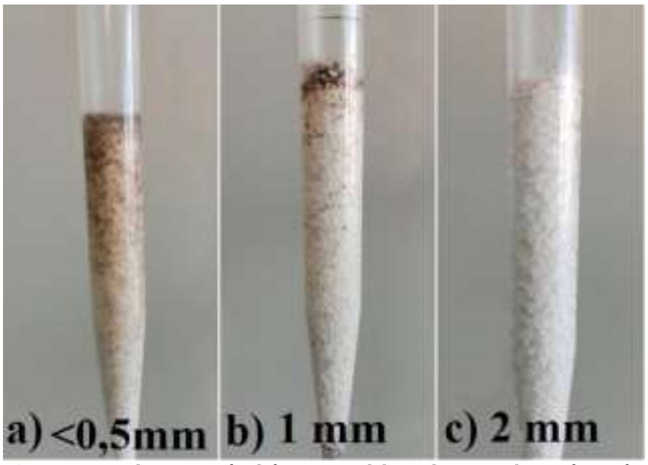

Figure 5:. Coalescence of oil from a model emulsion on the surface of a porous PTFE.

Removal of particles of oil from an emulsion, is confirmed by results of the chemical analysis of tests of an initial emulsion and filtrates of a model oil emulsion. Results on extent of cleaning of a model emulsion of oil products with filtration through the coalescing loadings from PTFE are presented in the figure 6.

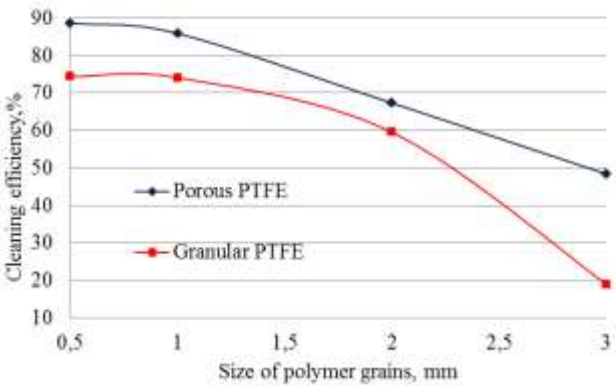

Figure 6:. Dependence of the degree of oil emulsion cleaning on the granulometric composition of the filtering charge of granular and porous PTFE.

The maximum extent of division of an emulsion of 89% for porous and 74,4% for granular PTFE is reached at the size of granules of the filtering loading of 0,5 mm. Increase in the size of grains of polymer up to 3 mm leads to decrease in efficiency of cleaning of oil products to 48% for porous and 19% for granular PTFE.
Extent of division of an emulsion porous PTFE is 10-30% higher in comparison with granular polymer. The efficiency of cleaning optimum in the range of the size of PTFE grains from 0,5 to 1,5 mm, and filtration speed for granular PTFE is optimum in all range of the size of grains, for porous PTFE the speed of filtration is optimum in the field of the size of granules from 1,5 to 3 mm.
Results of a research of the size of particles of oil in filtrates of an emulsion are presented in table 2 and in figures 7,8. ζ-potential of a disperse phase of filtrates of an emulsion is presented in table 2.

Table 2:. The values of the particle size and the z potential of the dispersed phase of the model oil emulsion and its filtrates.

Emulsion	Particle size, nm	ζ-potential, mV		
	Porous PTFE Grainy PTFE	Grainy PTFE	Porous	PTFE
Model oil emulsion	567-807, 2329-3315	-30±3		
Filtrate through granules				
3 mm	550-714, 1825-2368	879-1190, 2970-4020	-27±3	-32±3
Filtrate through granules				
2 mm	473-611, 1697-2335	575-822, 2400-3430	-26±3	-29±3
Filtrate through granules				
1 mm	298-366, 1187-1564	457-633, 2160-2350	-13±1	-23±2
Filtrate through granules				
0,5 mm	155-213, 762-1135	297-342, 1190-1690	-4,6±0,5	-10±1

ζ-potential of a disperse phase of a model oil emulsion is-30 mV, with increase in the size of granules of PTFE the ζ-potential of a disperse phase of an emulsion decreases. Occurs destruction of an emulsion, concentration of oil products decreases.

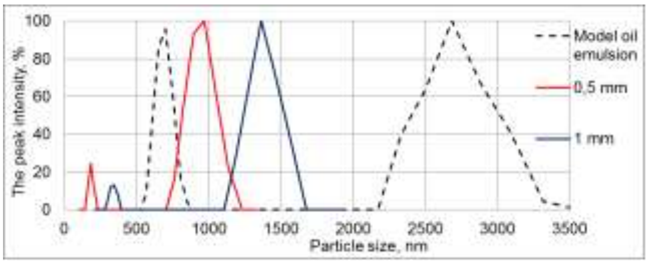

Figure 7:. Dependence of particle size distribution of the dispersed phase of emulsion filtrates on the granulometric composition of porous PTFE.

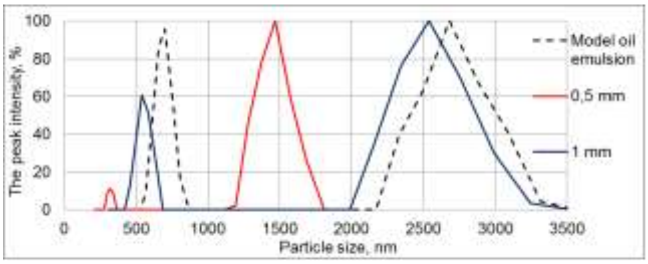

Figure 8:. Dependence of particle size distribution of the dispersed phase of emulsion filtrates on the granulometric composition of granular PTFE.

The size of particles of oil as a result of filtration through porous PTFE decreases from 567 nanometers to 155 nanometers. The coalescing loading works as the filter-coaletscer. Particles of oil are integrated and linger on a surface, in a time and space between granules. In case of filtration of an emulsion through granular PTFE of 3 mm in size, increase in the size of particles of oil from 3315 to 4020 nanometers is observed, this circumstance is connected with the fact that coalescent particles of oil are not late on the filtering loading of granules of 3 mm in size, and come to a filtrate.

Table 3:. Limit size of oil particles in the emulsion retained by PTFE granules

The size of the filtering load granules, mm	Limit size of oil particles, nm	
	with porous PTFE	with a granular PTFE
<0,5	155	297
0,5-1	298	457
1-2	473	575
2-3	550	879

Granules from porous PTFE coalesce more effectively and oil particles, than granular PTFE detain.

5. Conclusions

For division of oil emulsion by method of a coalescention used the filtering loadings from porous and granular PTFE. After filtration on a surface of granules the oil slick was formed.
The efficiency of removal of particles of oil from an emulsion and the speed of filtration depends on the size of granules and porosity of PTFE, the size of granules is less, the efficiency is higher. Also the efficiency of removal of oil products depends on the size of particles of a disperse phase of emulsions, and on value of ζ-potential of an emulsion as pushing away measures between particles of a disperse phase, that is an indicator of stability of system. The size of granules of the filtering loading is less the size of the deleted oil particles is less.
At filtration through granular loading from PTFE filtration speed high in comparison with the porous filtering loading, particles of oil are integrated, but badly are late. Therefore effectively to use the two-layer filtering loading: from above granular PTFE of granules of 3 mm in size for a coalescention of particles of oil and the lower layer porous PTFE with a size of granules of 1 mm, for effective retardation of the integrated oil particles.
The offered filtering loading can be used for effective division of oil, oil emulsions with sizes of particles from 0,2 to 10 microns and the content of oil products from 80 to 3000 mg/dm3.

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