

Dehydrating of heavy crude oil using radio-frequency and microwave radiation: What is better?

Liana Kovaleva^{a,*}, Rasul Zinnatullin^a, Rais Minnigalimov^b

^a *Baskir State University, 32, Z. Validi St., Ufa, 450074, Russian Federation*

^b *«TATIOLGAS», 24, Stroiteley, Almetevsk, 423450, Russian Federation*

(*corresponding author: liana@ic.bashedu.ru)

The problem of water-in-oil emulsion destruction is connected with many technological processes in oil-and-gas branch, especially in extracting and processing, preparation and transportation of oil when the rate of water blockage of the formation promptly increases. One faces the same problem in the process of liquidation of oil-sludge barns and while recycling their product.

High stability of water-in-oil emulsions is caused by the presence of heavy high-molecular and polar components in oil which, being adsorbed on a surface of water drops, form the armor envelopes. Thus the methods of influence on emulsion should be directed to reduce the strength of armor envelope, to destruct water drops and to create favorable conditions for their coalescence. One of these methods is the electromagnetic (EM) field impact, which is used in two frequency ranges: radio-frequency (RF) – from 10 to 100 MHz, and microwaves (MW) – in the range 300 MHz – 300 GHz.

The effect of the RF EM field on w/o emulsion mainly consists in destruction of an armor envelope due to the orientation polarization of polar components of oil (asphaltenes, resins, etc.), because expectably at these frequencies the resonant interaction of polar components with RF EM field takes place. Under the MW radiation action, the main object is water within the droplets which heats up and can destroy an armor envelope.

Experimental investigations of RF and MW influence on w/o emulsion samples have been carried out. Since interaction of substance with quickly variable EM fields is defined by resonant effect, frequency dependences of dielectric permeability and dielectric loss tangent for investigated samples have been measured in advance. Experiments were carried out by radiation of RF or MW EM energy into the vessel with water-in-oil emulsion. The RF generator with working frequency of 13.56 MHz and the MW generator with frequency of 2.4 GHz were used.

On Fig. 1 the results of researches of RF and MW fields influence and, for comparison, of usual thermal heating for two emulsion samples are presented. It is important to note, that the reached temperature in all experiments was one and the same.

The figure shows, that for sample №1 (on the left) the dehydration process occurs most intensively under the RF EM field impact (curve 1). It is connected with the used radio frequency which is the

resonant frequency in relation to polar components of the armor envelopes covering droplets of water.

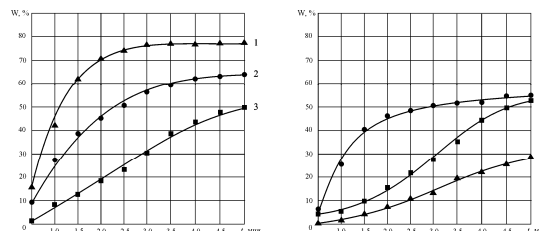


Fig.1. Dynamics of stratification of two emulsion samples at various kinds of EM influence: 1 – RF; 2 – MW; 3 - thermal heating.

After that, the armor envelopes collapse, and droplets of water have an opportunity to coalescence. It should be added, that in both cases, the heating of phases of the emulsion system takes place at different rates. This explains the presence of the temperature gradient on the water-hydrocarbon fluid interface. And we can also say, that under RF or MW influence on w/o emulsion not only heating phenomenon takes place. It is proved by lower values of curve 3.

While processing the sample №2 (on the right picture on Fig.1), radio frequency has not coincided with resonant frequency of polar hydrocarbon components. In this case, the method of the MW influence turned out to be the most effective. However, sometimes when destructing armor envelopes under MW influence the "injection nozzle" phenomenon occurs. As a result, droplets of water become even smaller, and consequently, emulsion becomes more stable. It can be seen in the photos taken during one of the experiments (Figure 2).

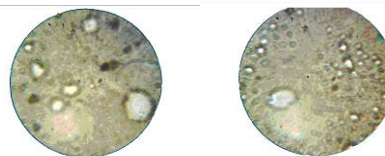


Fig.2. Photos of a water-in-oil emulsion structure before and after MW influence.

As a result of carrying out many experiments it has been established that, the use of EM radiation, both radio-frequency and microwaves, can be successfully applied for dehydration of heavy crudes. It is necessary to note, that in case of RF field it is practically always effective. But In the case of MW it depends on strength of armor envelope, and it can sometimes lead to negative result.