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THEORETICAL BASES FOR THE IMPLEMENTATION OF THE PROCESSES TO REDUCE VISCOSITY IN THE CONDITIONS OF NATURAL RESERVATION

Abstract. A matrix of space-time interactions occurring at the phase interface for films of different origin has been developed. It shows the types of controlled processes and methods of influence on the phase boundary to obtain the specified properties.

Key words: phase boundary, oil, water, quartz, matrix, space-time.

The fact of the predominance of high viscosity oils in modern oil fields makes it necessary to search for new geotechnologies that will reduce the cost of hydrocarbons (HC). Therefore, our work develops the idea of using the field as a natural reactor. For the first time this hypothesis was expressed by Lomonosov [1]. Then it was convincingly substantiated [2-4, 11-16] by other researchers in different parts of the globe [5-8, 17-23]. In our work, laboratory studies have shown the viability of this hypothesis for two and three component phase boundary. In industrial conditions at the Embamunaygas field, the processes of hydrogenation under conditions of natural occurrence were carried out by the authors [5] in 2017. Here, the decomposition of water was carried out chemically using hydro-reactive substances based on activated aluminum. Positive results of laboratory [6] and industrial tests require theoretical substantiation to explain the mechanisms of hydrocarbon hydrogenation under conditions of natural occurrence. Due to the fact that all processes begin at the phase boundary of this state, special attention is paid, as the phase boundary has the properties of both phases that it shares.

For the nano-level consideration, a matrix of basic interactions within the space-time responses of various forms of fluid to external influences has been developed.

Table 1 shows the main responses (processes) for films of organic and inorganic compounds.

Table 1 – Software module of interaction on phase boundary (3x3) (nano-level consideration)

Consideration levels, m	Frequency range, (Hz)s^{-1}			
	Films of liquid metal melts10^{-12} -10^{-15}	Liquid film 10^{-12} -10^{-9}	Films of organic compounds 10^{-9} -10^{-6}	Type of controlled process
Electronic > 10^{-12}	Elastic and inelastic scattering (exo emission)	Ionization	Radiation chemical reactions (radiolysis)	Phase nonequilibrium
Crystallographic > 10^{-9}	PhotoTransformation	Surface active processes	Structuring, oxidation, reduction	Concentration disequilibrium
Textural > 10^{-6}	Heat generation	Sorption	Polymerization (synthesis, destruction)	Interfacial disequilibrium
The method of controlling the state of phase boundary	Changes in contact conditions for heterogeneous phases	Resonant interaction mode	Capacitive parameters of contacting phases	

The developed matrix, made in the coordinates of the space-time parameters of interfaces of different composition, has 3 consideration nano-levels:

- electronic, for scales>10^{-12} m;
- crystallographic, for scales characteristic of the crystalline state;
- structural - for the size of the molecular level of consideration.

Three types of interfaces, differing in the frequency of responses to external influences, are considered:

- films of liquid melts;
- films of liquids of inorganic substances;
- films of organic substances.

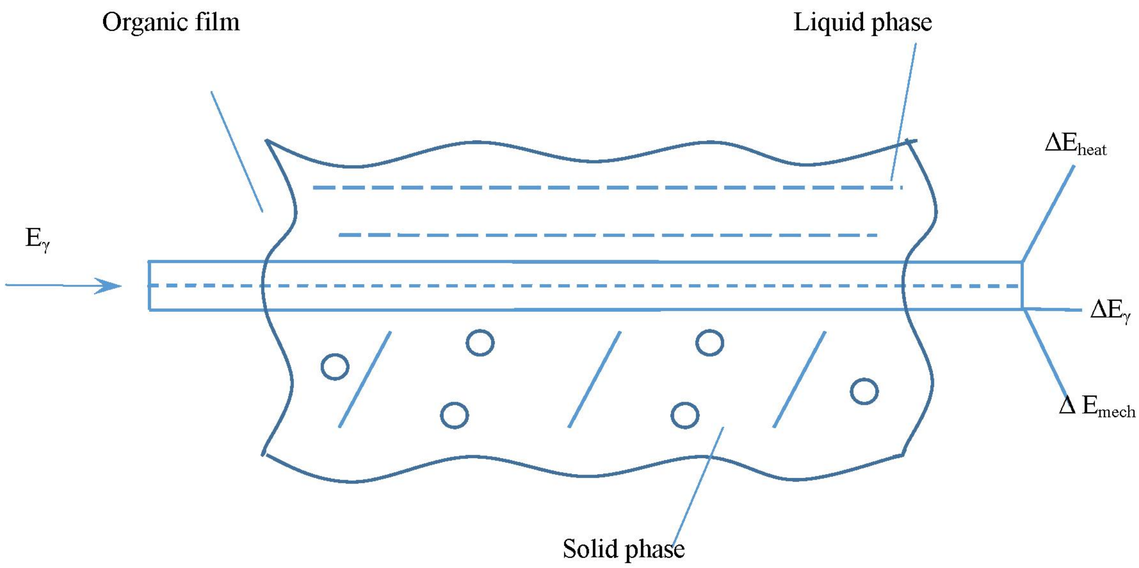
For each state of the phase boundary, the type of process it controls is defined, which are listed in response types.

In addition, methods for controlling the phase boundary were identified.

So according to the spatial attribute of the electronic level of consideration (horizontal row of the matrix), the types of response to external influence are exoemission, ionization and radiolysis. The driving force for the implementation of these processes is the intraphase disequilibrium that occurs when exposed, which can be controlled using 3 types of changes in the state of the film itself (the bottom row of the matrix). This can be done by low-energy methods such as:

- changes in the contact conditions of heterogeneous phases, for example, taking into account the effects of focusing;
- by changing the resonant parameter of one of the components of the boundary;
- the change in capacitive ratios separated by phase boundaries.

As an example, we consider the transforming potential of a film of an organic compound (HC) for the listed levels of consideration. Here, the types of external response are radiolysis, redox and polymerization-depolymerization reactions (vertical column for organic films). Here, at the electronic level of consideration, the frequency of external influence is within 109 ÷ 106 Hz. This means that intraphase nonequilibrium (activation of the boundary) can be accomplished with the help of electromagnetic or mechanical vibrations. In the specified frequency range, γ-rays, thermal oscillations, and ultrasonic waves have such capabilities.In the course of the resulting valuable reaction, they will ensure a change in concentration between the separated phases and within the film itself according to the scheme:



The scheme of film interactions (HC) at the phase boundary

Figure shows a diagram of the appearance of responses at the interface of a fluid-containing system under an external exposure on an organic film by the γ-radiation frequency. These high-frequency vibrations, passing through the film, are partially transformed under the influence of its structure and at the output we have:

$$E_\gamma \to E_{heat} + E_{mech} + E`_\gamma , \quad (1)$$

where E_γ – γ-radiation energy; ΔE_{heat} – energy of the IR spectrum of mechanical vibrations; $E`_\gamma$ – unabsorbed gamma rays energy.

Here it can be seen that as the scale of structural elements decreases during the response, new forms of external energy conversion from γ-radiation of the electromagnetic spectrum to mechanical vibrations of the thermal (IR) and ultrasonic (US) ranges appear. In the absence of resonance manifestations, these responses have a linear dependence on the frequency of conversion.

To do this, it is enough to know the space-time relations of the acting flow, which are interconnected with the speed υ by the universal linear relationship:

$$\upsilon = \lambda \nu, \quad (2)$$

where λ – the wavelength; ν – the frequency.

The response parameters depend on the speed properties of the perceiving medium and, depending on their nature, have linear and power relations [8]:

- for electromagnetic oscillations:

$$\upsilon = \frac{c}{n}; \quad (3)$$

- for mechanical waves in a solid (speed of sound):

$$\upsilon^2 = \frac{E}{\rho}; \ \upsilon^2 = \frac{G}{\rho}; \quad (4)$$

- speed of sound in liquids:

$$\upsilon_{ж}^2 = \frac{\sigma}{\rho}; \quad (5)$$

- surface wave velocity in fluid:

$$\upsilon_{П}^2 = gh , \quad (6)$$

here E is Young's modulus, ρ is density; G is the shear modulus; σ – surface tension.

The interaction mechanism in each case is determined by the speed parameters of the phases in contact with each other. Thus, the state of the phase boundary will change. Thus, by changing the state of the phase boundary (film), it is possible to control the response processes in the contacting media (in this example, at the boundary of the organic film).The quantitative ratios in the course of interaction obey A. P. Smirnovs law. [9].

The obtained experimental results on the study of the spectral parameters of the response to external influence showed a good convergence of the obtained data with a theoretical ratio.

To solve the problems of digitalization of technological processes, it is necessary to have knowledge of all types of external response for nano and macro levels of consideration. These responses should contain information that is distributed over spatial-temporal characteristics, each of which reflects the energy potential of the manifestation capabilities of a particular process depending on the scale of the structural elements and the frequency (temporal sign) of their oscillations around the equilibrium position.

For this case, a matrix table 2 of the matching of processes has been developed inherent in all types of reactions to external influences for four levels of consideration, differing from each other by three orders of magnitude:

- intraatomic;
- interatomic;
- intramolecular;
- intermolecular.

Table 2 – General view of the matching matrix for the selection of resonant conditions for the interaction of dissimilar substances

Reaction type / Level of consideration	Solid phase	Liquid phase (petrochemistry)	Gas phase (pyrolysis, polymerization)	Phase boundary (energy converters)
Intraatomic	Ionization potential, electron work function	Refractive index	Polarization	Atomic heat capacity electrode potential
Interatomic	Breaking energy, communication atmosphere	Dissociation energy	Sound speed	Electrodependence, sorption
Intramolecular	Molecular breaking energy	Specific heat, sound speed, density	Molar heat capacity	Thermal conductivity electrical conductivity
Intermolecular	Lattice parameter	Ion radius	Covalent radius, free path length	Diameter pairs, interfacial surface contact potential difference

Energy ratios are determined by the type of chemical reactions:
- solid phase;
- liquid phase
- gas-phase;
- phase boundary.

Thus, the developed correspondence matrix for selecting resonant interaction modes covers a wide range of phenomena inherent in all substances in different states. Practical use of such a matrix allows to:
- select the type of resonant interaction;
- determine catalytically - active substances;
- use the necessary scale features to achieve the conditions of multiplicity;
- harmonize the electrical and mechanical methods of converting external energy to obtain given properties.

After creating such matrices for nano and macro levels of consideration, it becomes possible to implement digitalization processes using the following algorithm:
- determination of the interaction mechanism at the phase boundary;
- identification of the level of consideration by frequency;
- identification of the level of consideration by spatial attribute;
- determination of the prevailing process;
- selection of a specific process control method.

According to the results of the analysis of the types of interaction at the phase boundary between the phases, the following conclusions:

1. The mechanisms of interaction at the phase boundary of the phases it separates depend on the space-time ratios of the boundary itself and the substance of the neighboring phases. The types of responses to external forcings are determined for three levels of consideration: electronic, crystallographic and structural (molecular).

2. As a response to an external effect, there are corresponding to each level types of disequilibrium: intraphase, concentration, and interphase. It provides the appearance of driving forces (transformation) of a specific response, the mechanisms of which are developed by mathematical and physical models.

3. It is shown that, depending on the type of film coating, there are 3 types of control processes during which the state of the phase boundary changes. Such methods are: changing contact conditions, resonant interaction mode and changing capacitive parameters of the contacting phases.

4.A mathematical equation is proposed to determine the quantitative parameters of the interaction with external influences for nano-levels of consideration.

5. An algorithm has been developed for the digitalization of all types of response to external influences according to space-time features.

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ТАБИҒИ ЖАҒДАЙ ШАРТТАРЫНДАҒЫ ТҰТҚЫРЛЫҚТЫ ТӨМЕНДЕТУ ПРОЦЕССТЕРІН ІСКЕ АСЫРУҒА АРНАЛҒАН ТЕОРИЯЛЫҚ НЕГІЗДЕР

Аннотация. Фазалардың бөліну шекарасында өзара болып жатқан шығу тегі әртүрлі пленкалар үшін, кеңістік-уақыт матрицасыэзірленді .Берілген қасиеттерді алу үшін фазалардаың бөліну шекарасынаәсер ету әдістері және басқарылатын процесстердің түрлері көрсетілген.

Түйін сөздер: бөліну шекарасы, мұнай, су, кварц, матрица, кеңістік-уақыт.

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ТЕОРЕТИЧЕСКИЕ ОСНОВЫ ДЛЯ РЕАЛИЗАЦИИ ПРОЦЕССОВ СНИЖЕНИЯ ВЯЗКОСТИ В УСЛОВИЯХ ПРИРОДНОГО ЗАЛЕГАНИЯ

Аннотация. Разработана пространственно-временная матрица взаимодействий, происходящих на границе раздела фаз для пленок разного происхождения. Показаны виды управляемых процессов и способы воздействия на границу раздела фаз для получения заданных свойств.

Ключевые слова: граница раздела, нефть, вода, кварц, матрица, пространство-время.

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