To the Problem of Mathematical Modeling of the Oil Deposit Processes

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***Abstract*— The approaches to improve the effectiveness of oil field exploitation using mathematical models of the oil deposit processes for forecast oil well debit are realized. It has been shown that using formula Kolmogorov-Erofeev allowed to receive more adequate model. On the base system analysis of the oil deposit processes was carried out the selection and estimation of important oil deposit parameters and indexes using on the mathematical modeling.**

***Key words*— mathematical modeling; cumulative; approximation; oil; water; stratum; liquid**

I. Introduction

One of the topical problems of oil extraction (OE) industry is oil return (OR) increasing. It is known, that an OE coefficient (K_e) changes in the range $0.1 \leq K_e \leq 0.7$ in average ≤ 0.5 [1]. One of the main cause of low OE is molecular surface processes occurred on the oil-rock-water boundary [2, 3]. Availability hydrophobized sections in the stratum conditioned by theirs direct contact with oil and consequently adsorption surface active oil components (SAOC) on the stratum capillary canals (SCC) surface. Comparison SCC radius values (r_c) and the thickness oil boundary layer (h_0) and also taking into consideration predominance in the stratum hydrophobing surface (68-84%), it is possible to assume that considerable part of the oil residual in the stratum there is in boundary-connected stages [1, 4]. Therefore, without take into consideration this factor the modern mathematical modeling (MM) methods of the oil deposit (OD) and OE intensify (OR increasing) using in the different subjects, in that number existing in late stage exploitation is less successful.

II. Problem Formulation

Receiving adequate MM OD required system analysis of the processes occurred in the OS and choosing important parameters and index (CIPAI) including to the MM. The data necessary for oil field exploitation: establishment regulation and control OS regime and well exploitation. Therefore, incorrect problem formulation bring numerous authors to that, what every limited approximate small arbitrary fragments time from the total exploitation processes of the OD period using serious limits [5]. Consequently grounded selection and estimation of importantly parameters and indexes of the OD using system approach is one of the topical problems.

III. Problem Solution

Taking into consideration mentioned above and specific peculiarity (physic-chemical and thermohydrodynamical) characteristics of the OD on base system analysis unlike the existing models in the paper carrying out CIPAI of OD. As a results of the investigation by the structural and classification scheme are shown in fig.,

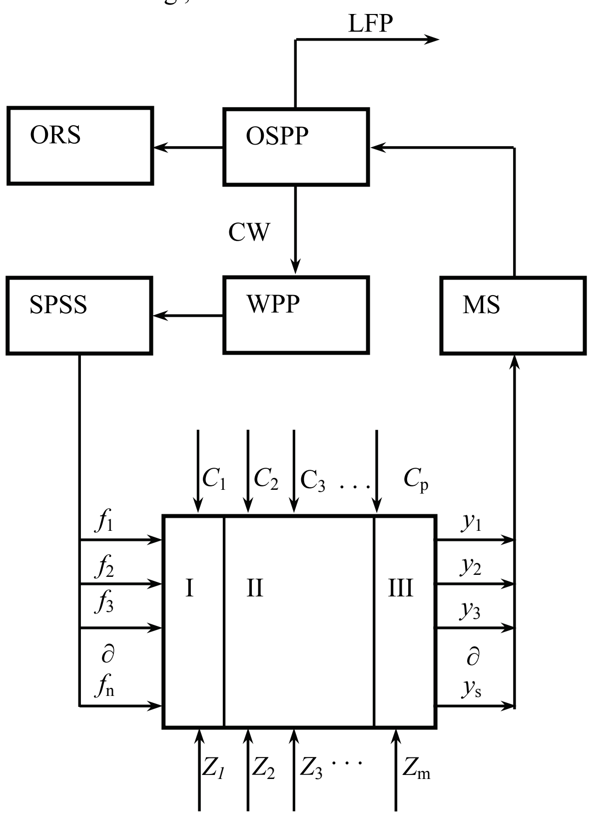

Figure 1. Oil field structural scheme.

where I, II, III are the relative water pumping, intermediate filtration and oil well debit zones; SPSS is the stratum pressure supporting section; MS is the measuring section; COPP is the thermochemical oil preparation plant; WPP – the water preparation plant;

ORS - the oil registration section; CW - the clearance water; LFP - large petrol fraction; f_i - the entrance indignant quality parameters in which quantative for the demanded frequencies determined by laboratories methods, in particularly: f_1, f_2 - the relative concentration oil and mechanical admixture in the pumping water (PW); f_3, f_4 - the relative salts concentration and composition in the PW; z_j - the OD stage parameters in which determined by indirect methods using outlet measuring data in particularly: z_1, z_2 - the relative oil viscosity and density; z_3, z_4 - the relative stratum porosity and permobilities; z_5, z_6 - the relative stratum and fluid compressority coefficients; z_7 - the moistening rocks by PW; z8 - the colmatation coefficient; z_9 - the depelitisation coefficient; z_{10} - the absorption layer thickness; z_{11} - the stratum pressure gradient; z_{12} - the capillary pressure; c_k - the control parameters in which measured directly in particularly; c_1, c_2 - the relative PW rate and pressure; c_3, c_4 - the relative specific surface active substance (SAS) rate and CO_2 rate; c_5, c_6, c_7, c_8 - the relative microbiological, electrical, mechanical and magnetically influence to the stratum; y_q - the outlet indexes in which either measured directly or determined using MM in particularly: y_1, y_2, y_3 - the relative stratum liquid, oil and water well debit; y_4 - the gaseous factor; y_5 - the OE coefficient.

In the world practice of the oil extraction for determining technological effectivity (TE) of the stratum ORI methods and oil extraction intensification inclusive: thermal, gaseous, chemical, physical, microbiological and hydrodynamical influence, widely used differential and integrate form two-three-four parametrical forcing out. Using this are makes attempt evaluate TE of geology-technical measures (GTM) prognosis extraction part oil stocks, evaluation water content in the extraction product, compensation dynamics PW.

The search of engineering solution bring to the convenient in practical view using Kolmogorov-Erofeev kinetical model [5, 6], intended for prognosis problems in the case MM of the OD:

$$\frac{dQ_k(t)}{dt} = \lambda(t)[1 - Q_k(t)] \tag{1}$$

$$\lambda(t) = abt^{(a-1)} \tag{2}$$

where $\lambda(t)i\Delta$ is the output rate oil stocks; a, b are the relative approximate coefficients (a>0, b>0); $Q_k(t)$ is the cumulative oil extraction for t moments.

As a result of solution (1) we have:

$$Q_k(t) = 1 - e^{-bt^a} \tag{3}$$

Time-raw main OD exploitation index current [$Q_k(t)$] oil-water mixture, oil and water choice curves is a clear examples characterizing evaluation stratum system. That allowed to A.Shahverdiyev [6] show change OE at the time using nonlinear evaluation equation:

$$\frac{dQ_k(t)}{dt} = a_1 Q_k(t) - a_{11} Q_k^2(t) \quad . \tag{4}$$

where $a_1 > 0$ is the OE increased coefficient;

$a_{11} > 0$ is the OE loss coefficient.

In the case analytical solution (4) for the initial condition $t = 0$, $Q_k(t) = Q_0$ we have:

$$Q_k(t) = \frac{Q_0 a_1 e^{a_1 t}}{a_1 - a_{11} Q_0 + a_{11} Q_0 e^{a_1 t}} \quad . \tag{5}$$

For using (1)-(3) one can valuated the coefficients *a, b*. For this we can equate (1) and (3), also (2) and (4). In result we have two system of equation:

$$\lambda(t)[1 - Q_k(t)] = a_1 Q_k(t) - a_{11} Q_k^2(t) \quad , \tag{6}$$

$$1 - e^{-bt^a} = \frac{Q_0 a_1 e^{a_1 t}}{a_1 - a_{11} Q_0 + a_{11} Q_0 e^{a_1 t}} = B(t) \quad . \tag{7}$$

From the (7) we get:

$$\lambda(t) = \frac{a_1 Q_k(t) - a_{11} Q_k^2(t)}{1 - Q_k(t)} = A(t) \, , \tag{8}$$

where the a_1, a_{11}, $Q_k(t)$, $A(t)$ and $B(t)$ values are determined using processes identification MM (4) and (5) at the t moment.

Substitute (8) to (2) we have:

$$b = \frac{A(t)}{at^{a-1}} \quad . \tag{9}$$

If substitute (9) with (7) we have:

$$a = \frac{A(t) \cdot t}{ln[1 - B(t)]} = \frac{A(t) \cdot t}{ln\, B^*(t)} \, . \tag{10}$$

If substitute (10) with (9) we get:

$$b = \frac{\ln B^*(t)}{t^{\frac{A(t)\cdot t}{\ln B^*(t)}}} \tag{11}$$

IV. CONCLUSION

And so finally according to the mentioned above it may be concluded that we can use famous formulas for more adequately predicted for the oil well debit change. In addition in this paper are conducted system analysis of the OD processes, selection and estimation important OD parameters and indexes.

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