Having given, that Q (h_0; H_0) is equal to $Q_{VL} = \mu_{BL,} \omega_{BL} \sqrt{2gH}$ and substituted (3) into (1), we'll yield the following:

$$\omega_K \frac{dH}{dt} = \left(\frac{\partial Q}{\partial h}\right)\Bigg|_{h=h_0} \cdot \Delta h + \left(\frac{\partial Q}{\partial H}\right)\Bigg|_{H=H_0} \cdot \Delta H. \quad (4)$$

Having given, that

$$\frac{dH}{dt} = \frac{d(H - H_0)}{dt} = \frac{d\Delta H}{dt},$$

we'll yield the following:

$$\omega_K \frac{d\Delta H}{dt} = \left(\frac{\partial Q}{\partial h}\right)\Bigg|_{h=h_0} \cdot \Delta h + \left(\frac{\partial Q}{\partial H}\right)\Bigg|_{H=H_0} \cdot \Delta H. (5)$$

So, the resulting equation of the transient regime (e.g. the dynamics) in the coordinates' increments, we'll give the dimensionless form, by means of the h and H relative deviations introducing:

$$x_{INPUT} = \frac{\Delta h}{h_H};$$

$$x_{OUT} = \frac{\Delta H}{H_H}, \quad (6)$$

where h_H and H_H – are some constant baseline values of the water level and the moving (in our case, the head in the over – membrane chamber).

Having substituted the Δh and ΔH values, we'll get the following:

$$\omega_K h_H \frac{dx_{HX}}{dt} - h\left(\frac{\partial Q}{\partial h}\right)\Bigg|_{H=H_0, h=h_0} \cdot x_{INPUT} = H_H + \left(\frac{\partial Q}{\partial H}\right)\Bigg|_{H=H_0, h=h_0} \cdot x_{OUT}. \quad (7)$$

For the dimensionless receiving of all the equation terms, we'll divide it by the coefficient x_{IN} and then, having taken the Laplace transforms (e.g. the entries in the pictures, or in the operator form), we'll obtain the dynamics equation, in the following form:

$$(T \cdot p - 1)\, x_{INPUT} = Kx_{OUT}, \quad (8)$$

where $T = \dfrac{\omega}{\left(\dfrac{\partial Q}{\partial h}\right)\Bigg|_{H=H_0}^{h=h_0}}$ – the time constant, having obtained from the equation (7), by means of dividing by the coefficient at $x_{INPUT;}$

$$K = \frac{H_H \left(\dfrac{\partial Q}{\partial H}\right)\Bigg|_{H=H_0}^{h=h_0}}{h_H \left(\dfrac{\partial Q}{\partial h}\right)\Bigg|_{H=H_0}^{h=h_0}}$$ – is the transfer coefficient;

p – the symbol (e.g. the operator) of the differentiation.

The characteristic equation of the equation (8) will have the following form:

$$T \cdot p - l = 0, \quad (9)$$

whence

$$p = \frac{l}{T}; \quad (10)$$

$$\frac{\partial Q}{\partial h}\Bigg|_{h=h_0,\, H=H_0}$$

Thus, from the equation (10), it is clear, that the check valve operation will be stable, if p has the negative real part. So, the time constant T, in this case, must be the negative one, i.e. the denominator $\left(\dfrac{\partial Q}{\partial h}\right)$ will be less than zero, in other words, it is presented itself the decreasing function.

Indeed, at the h increase, the flow rate through the calibrated hole is decreased. Thus, here, there is always observed the $\left(\dfrac{\partial Q}{\partial h}\right) < 0$ inequality.

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THE TECHNOLOGICAL PROCESS RESEARCH FOR WELLS' OPERATION

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It is necessary to be considered the various factors research challenge at the wells' protection process from their sanding up, for the theoretical researches confirmation.

I. The laboratory – bench and development tests have been carried out, without interrupting the wells' operation technological process.

– **The Well № 1** – the water hammer presence at the pump restarting, and, as a result of the increased turbulence (e.g. flows whirling pool), there is the abundant occurrence of the suspended particle:

$$\sum = S \cdot h \cdot q \cdot \rho; \qquad (1)$$

$$V \cdot \rho = m_1; \qquad (2)$$

$$m_1 \cdot q = F_1. \qquad (3)$$

– The Well № 2 – at the KOP-1.0 check valve presence, with the adjustable opening time, by the complete water hammer absence, at the repeatedly restarted deep well pump, and, therefore, there are the reduced turbulence phenomenon and the complete suspensions absence in the water:

$$\sum = S \cdot h \cdot q \cdot \rho; \qquad (4)$$

$$V \cdot \rho = m_2; \qquad (5)$$

$$m_2 \cdot q = F_2 \qquad (6)$$

and as a result of:

$$q > a; \quad F_1 < F_2.$$

II. The production process testing and the corresponding technological tests – this is the simultaneous water pumping during 10 days and nights (e.g. 240 hours), with the use of the two turbine meters of the BB-50 cold water for the water volume measuring, having flowed through the well № 1 and the well № 2 pipelines, simultaneously at the temperature up to 30 °C and the pressure up to 1 MPa:

The well № 1: The well № 2:

$$\sum = S \cdot \rho \cdot C_i^1; \qquad \sum = S \cdot \rho \cdot C_i^2; \qquad (7)$$

$$V \cdot \rho = m_1; \qquad V \cdot \rho = m_2; \qquad (8)$$

$$m_1 \cdot C_i = G_1; \qquad m_1 \cdot C_i = G_2; \qquad (9)$$

$$C_i^1 > C_i^2;$$

$$G_{1_i^1} > G_2,$$

where C_i – the specific concentration of the suspensions.

As a result, by the obtained data, we can see, the specific concentration of the sandy suspensions is very high and the volume of the settled sand is great, that in the well № 1, which has no the check valve with the adjustable opening time, and also the artificial structure of the pebbly filter. The specific concentration density is quite so small, that in the sedimentation tank, we don't find the settled sand in the well № 2, having equipped with the check valve with the adjustable the opening time, and the artificial pebbly filter structure.

The production – processing and technological (e.g. operating) experimental tests have already been carried out during the 3 summer months (e.g. 92 days and nights): June, July, and August – in the season of the greatest use of the water resources. So, the check valve KOP-1.0 had been temporarily installed at the production – processing and technological tests on the well № 1, as a result of which the completely different experimental data were received, which were then recorded in the tests log, where the sand content in the samples was decreased significantly, in comparison with the previous samples. The well flow rate has been remained the same, and it has been equaled to Q = 6,5 m^3/h or Q = 156 m^3/day, at the fine sand content 20 g per 1 m^3 water or 312 g/day.

So, the experimental data readings from the samples, having taken during the production – processing and technological tests during the 92 days and nights of the experiments have already been given the stable results by the production rate Q = 14,8 m^3/h. or 355,2 m^3/day, at the fine sand content 0,001 g/qm^3 in the well № 2, having equipped by the artificial pebble filter and by the check valve KOP-1.0, This was given us every reason to be believed, that the experimental tests had already been confirmed the choice correctness of the input parameters of the processes under their study.

So, the statistic data and the theoretical analysis results have already been allowed, according to the researches plan *A*, *B*, *C*, to be justified the setting ranges and the varying levels of the input parameters to be obtained the statistics equations and the aerohydrodynamics at the operating pumping out:

$$\sum_{j=1}^{m} P_j = 0; \qquad (10)$$

$$\sum_{k=1}^{n} \frac{dp_k}{dt} = J(P_k, C_k, t), \qquad (11)$$

where J – the change in pressure; P_k – the pressure; C_k – the suspensions concentration; t – the time.

The equation of the aerohydrodynamics flow patterns:

$$\sum_{k=1}^{n} \frac{dp_k}{dt} - \sum_{j=1}^{m} K_j \cdot P_j = \sum_{m=1}^{l} \sum_{k=1}^{n} J_m(P_k^m, C_k^m, t); \qquad (12)$$

– the increase (flow rate) quantity of flow equation:

a) by the inflow increasing;

b) by the filtration coefficient increase:

$$\sum_{m=1}^{l} Q_m = V_{d.v} \cdot K_f \frac{dy}{ds}, \qquad (13)$$

where $V_{d.v}$ – the depressive funnel volume; K_f – the filtration coefficient.

– the external and internal forces interaction equation at the artificial pebbly filter installation:

$$\sum_{i=1}^{k} F_1 + \sum_{j=1}^{m} F_j = 0; \qquad (14)$$

– the kinetics and aerohydrodynamics equation for the nominal characteristics:

$$fJ(P_K, C_K, t)dt = \sum_{k=1}^{n} P_k. \qquad (15)$$

The variation limits in the factors, under the production – processing and technological exploitation conditions, at the maximum water selection and sampling intake regime, have been allowed to be taken the mathematical description making up production of the initial and the boundary conditions, the differential equations of the processes:

$$\frac{\partial P}{\partial t}+V\frac{\partial P}{\partial x}=f_1(P, C; K_1, K_2; X, t). \qquad (16)$$

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