THE NEW NUMERICAL METHOD A CALCULATION OF TRANSIENTS PROCESSES IN THE OIL - PRODUCT MAINS PIPELINE WITH CENTIFUGAL PUMPING STATIONS SO FOR CONSECUTIVE FEEDING OF SEVERAL OIL - PRODUCTS

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ABSTRACT

The new numerical method a calculation of transients processes in the oil-products mains pipeline with centrifugal pumping stations is presented.

Keywords: oil, centrifugal pumping, numerical method, transients processes

I. INTRODUCTION

Now due to wide introduction of computer techniques in produce of engineering calculation, to creation of numerical methods of calculation of transient's processes in the mains oil-product pipeline pays steadfast attention.

One of effective numerical methods of calculation of dynamic processes in object with me distributed parameters, described by the equations in individual derivatives of hyperbolic type is the numerical method, is based on use of discrete analogue of the integrated equation of convolution [1-3].

In given article the further generalization and development of the given numerical method [1-3], for creation of method calculation of transients processes in the oil-product main pipeline with centrifugal pumping stations mains pipeline so for consequent feeding of several-products.

II. BODY OF THE TEXT

In given case main pipeline considered as endlessly lain with distributed parameters [1]. The transition processes in the main oil-products pipelines describes by the telegraph equations [1].

$$-\frac{\partial H_i}{\partial x} = K_1{}^i \frac{\partial Q_i}{\partial t} + K_3{}^i Q_i,$$

$$-\frac{\partial Q_i}{\partial x} = K_2{}^i \frac{\partial H_i}{\partial t}$$

$$0 \le x \le l_1 \qquad (1)$$

$$l_1 \le x \le L_2$$

where H_i, Q_i – change of pushing and flow rate to any of main oil pipeline to any moment of time: i=1,2, $k^i{}_1 = \frac{1}{gF}, k^i{}_2 = \frac{gF}{c_i^{\;2}}, k^i{}_3 = \frac{2a_i}{gF}, 2a_i = \frac{\eta_i \omega_{cp}}{2D}$ - Coefficient loss of inebriated by I.A.Charniy.

F- Cross section, D-inner pipe diameter, η_i – Darcy - Wasatch fraction factor, ω_{cp}- velocity of flow stationary regimes, c_i-the velocity of sound in flow, g-acceleration, L_2 -pipe length.=l_1+l_2

Entry conditions:

$$H(x,t)_{t=0}=H_0, \quad Q(x,t)_{t=0}=0$$

Where H_0 – entry pushing.

Boundary conditions:

$$H_1(x,t)_{x=0}=H_{1H}(t),\ H_1(x,t)_{x=l\,1}=H_{1k}(t),$$
$$H_2(x,t)_{x=}l_1=H_{2H}(t),\ H(x,t)_{x=L\,2}=H_H(t),$$

At times transient processes, boundary surface oil-products intend fixed.

Conditions of contact oil-products in the point x=l_1 will be $H_1(l_1,t)=H_2(l_1,t)$

$Q_1(l_1,t)=Q_2(l_1,t)$

Boundary condition in initial of pipe, and on boundary surface in initial of decision given task intend unknown. That meaning determine from decision of task.

In the initial of decision given task as unknown. It is determine for of decision given of task.

The equation of movement of the pumping us shale present as:

$$T_Д \frac{d\nu(t)}{dt} = Mg(t) - M_c(t), \qquad (2)$$

Where $T_Д = \frac{n_c}{M_Н} = \frac{\theta D^2}{375}$ constant of time, n_c – the synchrony current angular speeds of rotation of a rotor of the electric motor of the pumping

M_H - nominal moment, θD^{12} – the sun of the moments of inertia of pumping, $Mg(t) = \frac{M_д(t)}{M_H}$ - the rotating moment of the electric motor and the moment resistance of loading accordingly, $\nu(t) = \frac{n_д(t)}{n_c}$ - change speeds of rotation of a rotor of the motor.

In expression (2) rotating moment in nonlinear function

Mg(t)=Φ[ν(t)].

We shall present nonlinear dependence *Mg(t)=Φ[ν(t)]* as approximate its piece – linear functions as:

$$Mg(t) = \hat{a}_j \pm \hat{b}_j \nu(t), \qquad (3)$$

Where, $j = \overline{1, k'_0}, k'_0$ – - parameters of linearization for corresponding districts of mechanical characteristic of the engine.

The power characteristics of centrifugal pumping as approximate of expression:

$$(t) = \hat{C} \nu^3(t) + \hat{d} \nu^2(t) q_H(t), \qquad (4)$$

Where, $\hat{c}\ \hat{d}$ - parameters of linearization of power characteristics of pumping, $q_н(t) = \frac{Q_H(t)}{Q_{ном}}$ – change of few in the point x=0 of pipeline.

The moment resistance of loading accordingly determine from of expression:

$$M_c(t) = \frac{N(t)}{\nu(t)} = \hat{C} \nu^2(t) + \hat{d} \nu\ (t) q_H(t), \qquad (5)$$

The pushing characteristics of pumping ass approximate of expression:

$$h_{HC}(t) = a_1 \nu^2(t) - b_1 q_H^2(t) \qquad (6)$$

Where, a_1, b_1 – parameters of linearization of pushing characteristics of pumping.

The change of pushing on outlet of pumping determine from of expression:

$$h_H(t) = h_0 + h_{Hc}(t), \qquad (7)$$

We h_0 – are pushing on entrance of pumping.

The solution of system of the differential equations (1) under the accepted initial and boundary condition allow to receive the full information on change of angular pushing and the from rate, both on length of a column of pipeline, and on time.

At the decision of a task in view at the first stage it is necessary to receive replace images for functions H(x,t),Q(x,t).

By using this method, we shall receive expression for the specified functions in the operational form:

$$H_1(\chi, s) = \frac{sh\gamma_1(l_1 - \chi)}{sh\gamma_1 l_1} H_{1H}(s) + \frac{sh\gamma_1 \chi}{sh\gamma_1 l_1} H_{1K}(s) \qquad (8)$$

$$Q_1(\chi, s) = \frac{1}{b_1(s)} \frac{ch\gamma_1(l_1 - \chi)}{sh\gamma_1 l_1} H_{1H}(s) - \\ - \frac{1}{b_1(s)} \frac{ch\gamma_1 \chi}{ch\gamma_1 l_1} H_{1K}(s) \qquad (9)$$

$$H_2(\chi, s) = \frac{sh\gamma_2(L_2 - \chi)}{sh\gamma_2 l_2} H_{2H}(s) + \frac{sh\gamma_2(\chi - l_1)}{sh\gamma_2 l_2} \cdot \\ \cdot H_{2K}(s) \qquad (10)$$

$$Q_2(\chi, s) = \frac{1}{b_2(s)} \frac{ch\gamma_2(L_2 - \chi)}{sh\gamma_2 l_2} H_{2H}(s) - \\ - \frac{1}{b_2(s)} \frac{ch\gamma_2(\chi - l_1)}{sh\gamma_2 l_2} H_{2K}(s) \qquad (11)$$

Where $\gamma_i(s) = \sqrt{sk^i{}_2(sk^i{}_1 + k^i{}_3)}$ – operator constant of wave spreading, $b^i(s) = \sqrt{\frac{sk^i{}_1 + k^i{}_3}{sk^i{}_2}}$ – -- operator wave résistance pipeline with account of losses, S – operator of replace transformation.

On the base of the theorem of convolution [1, 3], passing from the equations (10), (11) concerning images to the equations concerning originals, we shall receive:

$$\int_0^t H_1(t-\theta, \delta_1) 1(\theta) d\theta - \int_{\frac{2l_1}{c_1}}^t H_1(t-\theta, \delta_1) k_1^1(\theta) d\theta = \\ \int_{\frac{2l_1\delta_1}{c_1}}^t H_{1H}(t-\theta) k^1{}_2(\theta) d\theta - \int_{\frac{2l_1(1-\delta_1)}{c_1}}^t H_{1H}(t-\theta) k^1{}_3(\theta) d\theta + \\ + \int_{\frac{l_1(1-2\delta_1)}{c_1}}^t H_{1K}(t-\theta) k^1{}_4(\theta) d\theta - \int_{\frac{l_1(1+2\delta_1)}{c_1}}^t H_{1K}(t-\theta) k^1{}_5(\theta) d\theta, \qquad (12)$$

$$\int_0^t Q_1(t-\theta, \delta_1) 1(\theta) d\theta - \int_{\frac{2l_1}{c_1}}^t Q_1(t-\theta, \delta_1) k^1{}_1(\theta) d\theta = \\ \int_{\frac{2\delta_1 l_1}{c_1}}^t H_{1H}(t-\theta) k_6^1(\theta) d\theta + \int_{\frac{2l_1(1-\delta_1)}{c_1}}^t H_{1H}(t-\theta) k_7^1(\theta) d\theta - \\ - \int_{\frac{l_1(1-2\delta_1)}{c_1}}^t H_{1K}(t-\theta) k_8^1(\theta) d\theta - \int_{\frac{l_1(1+2\delta_1)}{c_1}}^t H_{1K}(t-\theta) k_9^1(\theta) d\theta \qquad (13)$$

$$\int_0^t H_2(t-\theta,\delta_{i_1})1(\theta)d\theta-\int_{\frac{2l_2}{c_2}}^t H_2(t-\theta,\delta_{i_1})k_1^2(\theta)d\theta=$$

$$\int_{\frac{\delta_2^1 l_2}{c_2}}^t H_{2H}(t-\theta)k^2{}_2(\theta)d\theta-\int_{\frac{\delta_2^2 l_2}{c_2}}^t H_{2H}(t-\theta)k_3^2(\theta)d\theta+ \quad (14)$$

$$+\int_{\frac{\delta_2^3 l_2}{c_2}}^t H_{2K}(t-\theta)k^2{}_4(\theta)d\theta-\int_{\frac{\delta_2^4 l_2}{c_2}}^t H_{2K}(t-\theta)k^2{}_5(\theta)d\theta$$

$$\int_0^t Q_2(t-\theta,\delta_2)1(\theta)d\theta-\int_{\frac{2l_2}{c_2}}^t Q_2(t-\theta,\delta_{i_1})k_1^2(\theta)d\theta=k_2$$

$$\int_{\frac{\delta_2^1 l_2}{c_2}}^t H_{2H}(t-\theta)k_6^2(\theta)d\theta-k_2\int_{\frac{\delta_2^2 l_2}{c_2}}^t H_{2H}(t-\theta,\delta_2)k_7^2(\theta)d\theta-$$

$$-k_2\int_{\frac{\delta_2^3 l_2}{c_2}}^t H_{2K}(t-\theta,\delta_2)k_8^2(\theta)d\theta-k_2\int_{\frac{\delta_2^4 l_2}{c_2}}^t H_{2K}(t-\theta,\delta_2)k_9^2(\theta)d\theta \quad (15)$$

The integrated equations (12-15) can be solved numerically it to replace integrals with the sums. Therefore, using connection between continuous time t and discrete n as $T=nT/\lambda$ [1, 3] ($n=1,2,...E=l/c$), we make digitization of the equations (12), (13) at chosen interval T/λ replacing operations of continuous integration by summation using the formula of trapezium.
He instead (12), (13) we receive the following recurrent equation for functions determinations

$$H_1[n,\delta_1]=\sum_{m=r_1\lambda\delta_1}^{n}\begin{pmatrix}k_2^1[m]H_{1H}[n-m]+\\ k_2^1[n-m+1]H_{1H}[m-1]\end{pmatrix}-$$

$$-\sum_{m=r_1\lambda(1-\delta_1)}^{n}\begin{pmatrix}k_3^1[m]H_{1H}[n-m]+\\ k_3^1[n-m+1]H_{1H}[m-1]\end{pmatrix}+$$

$$+\sum_{m=0,5r_1\lambda(1-2\delta_1)}^{n}\begin{pmatrix}k_4^1[m]H_{1K}[n-m]+\\ k_4^1[n-m+1]H_{1K}[m-1]\end{pmatrix}-$$

$$-\sum_{m=0,5r_1\lambda(1+2\delta_1)}^{n}\begin{pmatrix}k_5^1[m]H_{1K}[n-m]+\\ k_5^1[n-m+1]H_{1K}[n-m+1]\end{pmatrix}+$$

(16)

$$+\sum_{m=0,5r_1\lambda}^{n}\begin{pmatrix}k_1^1[m]H_1[n-m,\delta_1]+\\ k_1^1[n-m+1]H_1[m-1,\delta_1]\end{pmatrix}-$$

$$-\sum_{m=1}^{n}\left(1[m]H_1[n-m,\delta_1]+1[n-m+1]H_1[m-1,\delta_1]\right)$$

$$-\sum_{m=0.5r_2\lambda\delta_2^2}^{n}\left(k_3^2[m]H_{2H}[n-m]+k_3^2[n-m+1]H_{2H}[m-1]\right)-$$

$$+\sum_{m=0.5r_2\lambda\delta_2^3}^{n}\begin{pmatrix}k_4^2[m]H_{2K}[n-m]+\\ k_4^2[n-m+1]H_{2K}[m-1]\end{pmatrix}-$$

$$-\sum_{m=0.5r_{l_2}\lambda\delta^4{}_2}^{n}\begin{pmatrix}k_5^2[m]H_{2K}[n-m]+\\ +k_5^2[n-m+1]H_{2K}[m-1]\end{pmatrix}+$$

$$+\sum_{m=r_2\lambda}^{n}\begin{pmatrix}k_1^2[m]H_2[n-m]+\\ +k_1^2[n-m+1]H_2[m-1,\delta_2]\end{pmatrix}-$$

$$-\sum_{m=1}^{n}\left(1[m]H_2[n-m]+1[n-m+1]H_2[m-1,\delta_2]\right)$$

(17)

$$Q_2[n,\delta_2]=k_2\sum_{m=0.5r_2\lambda\delta_2^1}^{n}\begin{pmatrix}k_6^2[m]H_{2H}[n-m]+\\ +k_6^2[n-m+1]H_{2H}[m-1]\end{pmatrix}+$$

$$+k_2\sum_{m=0.5r_2\lambda\delta^2{}_2}^{n}\left(k_7^2[m]H_{2H}[n-m]+k_7^2[n-m+1]H_{2H}[m-1]\right)-$$

$$+k_2\sum_{m=0.5r_2\lambda\delta^3{}_2}^{n}\begin{pmatrix}k_8^2[m]H_{2\kappa}[n-m]+\\ +k_8^2[n-m+1]H_{2\kappa}[m-1]\end{pmatrix}-$$

$$
-k_2 \sum_{m=0.5_2\lambda\delta^4{}_2}^{n} \begin{pmatrix} k_9^2[m]H_{2K}[n-m]+ \\ k_9^2[n-m+1]H_{2K}[m-1] \end{pmatrix} +
$$

$$
+\sum_{m=r_2\lambda}^{n}\left(k_1^2[m]Q_2[n-m]+k_1^2[n-m+1]Q_2[m-1,\delta_2]\right)-
$$

$$
-\sum_{m=1}^{n}\begin{pmatrix} 1[m]Q_2[n-m,\delta_2]+ \\ +1[n-m+1]Q_2[m-1,\delta_2] \end{pmatrix}, \tag{18}
$$

Where *I0[n],I1[n]* – Bessel functions of zero and first degree.The error of calculations connected, as the continuous functions characteristics smaller varied from the corresponding grid functions.

In (14), (15) for determinate meaning function $h_H[n]$ from recurrent formulas by x=0 we shall receive:

$$
q_H[n] = h_{nc[n]} + B[n], \tag{19}
$$

Where

$$
B[n] = \sum_{m=1}^{n}\left(h_{Hc[n-m]}k_2^{/}[m] + k_2^{/}[n-m+1]h_{HC}[m-1]\right) -
$$

$$
-\sum_{m=1}^{n}\left(q_{H[n-m]}1[m] + 1[n-m+1]q_H[m-1]\right)
$$

$$
k_2^{/}[n] = e^{-\frac{a\tau}{\lambda}n} I_0\left(\frac{a\tau}{\lambda}n\right)
$$

Expression (6) any may present in the discrete form:

$$
h_{Hc}[n] = a_1\nu^2[n] - b_1 q_H^2[n] \tag{20}
$$

Expression (16) with account (17) we shall:

$$
q_{H[n]} = \frac{-1+\sqrt{1+4b\left(a\nu^2[n]+B[n]\right)^2}}{2b} \tag{21}
$$

In (18) for determine meaning function $\nu_{[n]}$

(2) We shall:

$$
\nu[n+1] = \frac{T}{\lambda T_g}\left(Mg[n] - M_c[n]\right) + \nu[n], \tag{22}
$$

Where,

$$
Mg[n] = \hat{a}_j \pm \hat{b}_j\,\nu[n], \quad \nu[n]_{n=0} = 0
$$

$$
M_c[n] = \hat{c}\,\nu^2[n] + \hat{d}\,\nu[n]q_H[n]
$$

Received recurrent formulas (14), (15) are easily realized on the computer.

III. CONCLUSION

Thus, the new numerical method calculation of transients processes in the oil-products mains pipeline with centrifugal pumping stations is presented.

REFERENCES

1. *Pashaev A.M., Mehdiev A.Sh., Aliyev Y.A., Mamedov A.I.* New method determination flow oil, gas product in the main pipelines for measurement orifice meter with account real conditions – their dynamic regimes. Transactions of Azerbaijan National Academy of Sciences, series of physical – technical and mathematical sciences, 2005, № 3 (in Russian)
2. *Aliyev Y.A.* Numerical definition of transients in a column of boring pipes as object as object with the distributed parameters. Problems of power, 2004, № 1 (in Russian)
3. *Aliyev Y.A., Mamedov A.I.* Digital modeling of transients in the drilling electric drive with the distributed parameters with electromagnetic muft at failure of the drilling instrument. Materials of Second International Conference on Technical and physical Problems in Power Engineering, 6-8 September, 2004, Tabriz, Iran.