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THE HYDRAULIC RESONANT CAMERA AND HYDRAULIC OSCILLATORY CONTOUR WHEN DRILLING BY HYDRO DRUMMERS OF PROSPECTING WELLS

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ABSTRACT

Hydro resonant camera is movements or processes, which are characterized by certain repeatability in time are called fluctuations. Oscillatory processes are widespread in the nature and equipment, for example swing of a pendulum of hours, alternating electric current etc. At an oscillating motion of a pendulum the coordinate of its center of masses changes, in case of alternating current tension and current in a chain fluctuate. The physical nature fluctuation can be different therefore distinguish fluctuations mechanical, electromagnetic, etc., however various oscillatory processes are described by identical characteristics and the identical equations. From here expediency of uniform approach to studying fluctuation of various physical natures follows. For example, uniform approach to studying mechanical and electromagnetic fluctuation was applied by the English physicist D. U. Rayleigh (1842-1919), A. G. Stoletovy, Russian engineer experimenter P. N. Lebedev (1866-1912). Big contribution to theory development fluctuation made L. I. Mandelstam (1879-1944) and his pupils. (T. A. Trofimova., physics course, Moscow edition seventh "Higher school" of 2002).

Key words: Hydro resonant camera, Hydro drummers, Drilling, Hydro shock.

INTRODUCTION

In laboratory of hydro shock drilling of department of equipment of investigation of the Kazakh research institute of mineral raw materials, works on a reflector of hydraulic waves, in the seventeenth and the beginning the eightieth years. Were reflectors of hydro shock waves for drilling by PO-76,59 hydro drummers are created. Dipping reflectors differ simplicity in production and in service.

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Stream of flushing liquid, moving on a boring column reaches the valve of the hydro drummer and strikes blow. But over the valve, it was created a hydraulic wave which moves up and reaches knot of a branching and the part leaves up and dissipates, and the part goes to a deadlock branch of a reflector. Being reflected from the deadlock comes back to the valve at the time of its closing[3].

But the part of a hydraulic wave getting to a boring column comes back as the boring column too is the deadlock. The hydro resonant camera is similar to a tuning fork; in a tuning fork having knocked on a branch, we will hear a sound which extends extensively. Sound waves having reached a branch B influence to and it starts letting out fluctuations. Fluctuations from a branch B extend extensively and also reach a branch, but the distance between them is picked up so that having reached a branch they get in unison, in a step and the branch A starts fluctuating more strongly[3].

The hydraulic wave collects in the resonator (a branch 10) and arrives in a deadlock branch (a branch 8), being reflected from the deadlock it comes back to the resonator (a branch 10). If the hydro drummer valve blocks again the channel that there is a water hammer and a hydraulic wave again moves from the resonator to the deadlock (11) and back.

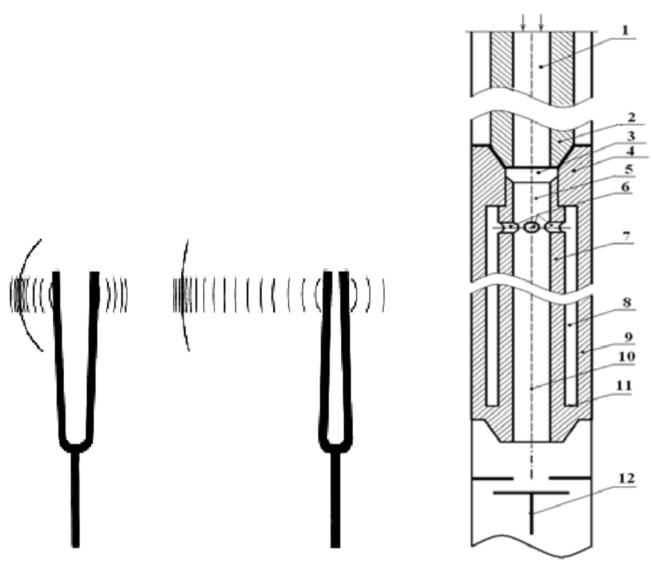


Fig. 1: Comparison with a tuning fork

In Fig. 2 the electronic oscillatory contour and a physical pendulum, which have similarity to a hydraulic oscillatory contour is shown.

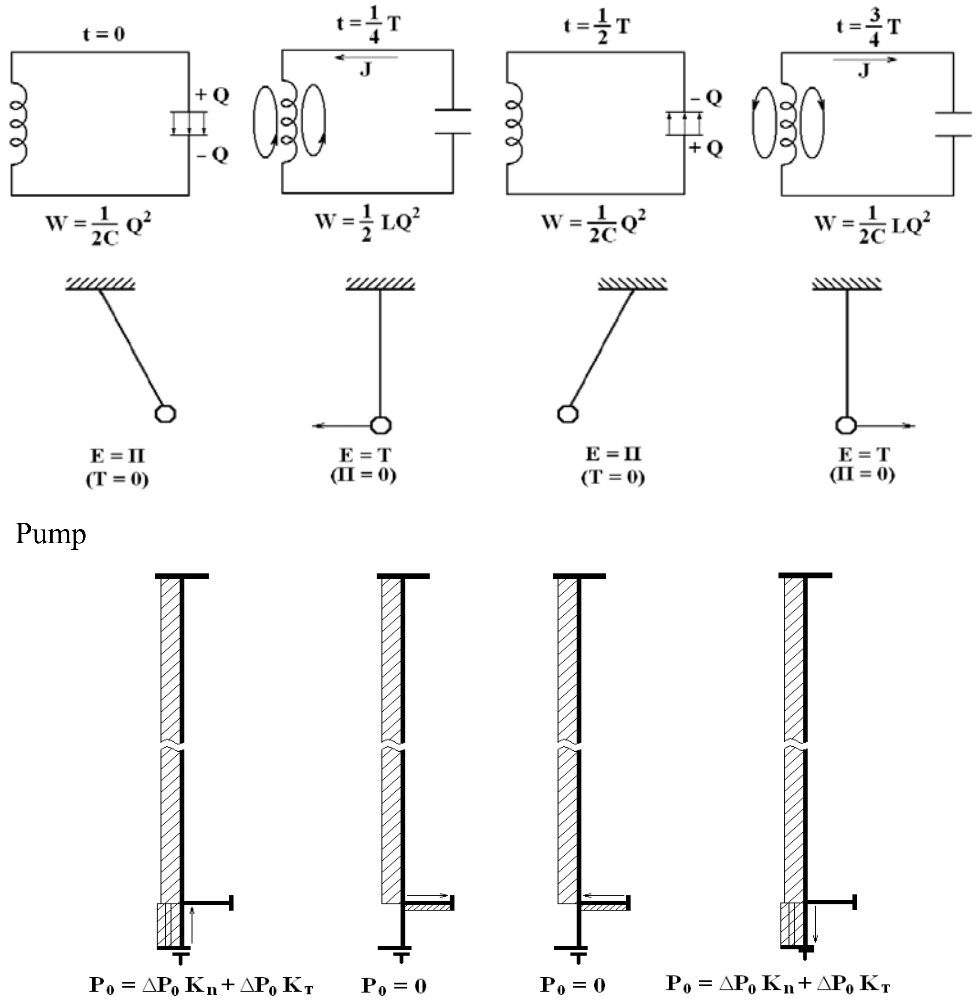
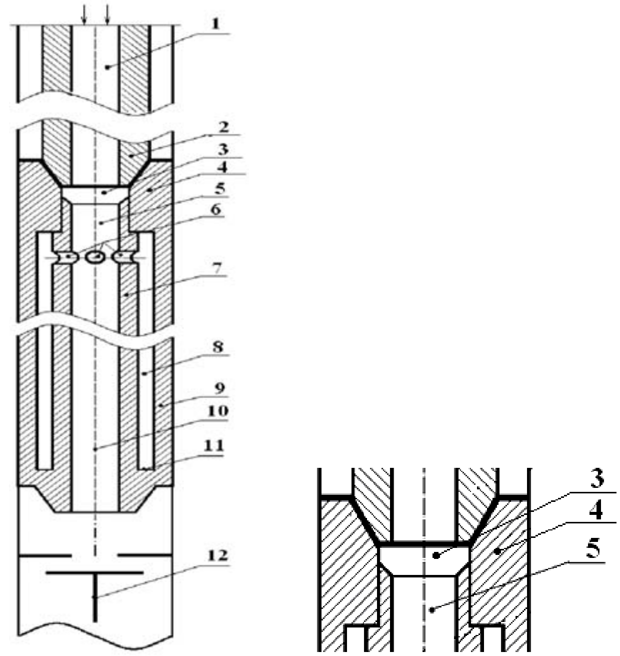


Fig. 2: Comparison with other oscillatory contours

Movement of hydraulic waves in the closed space of the pipeline (a boring column)

The phenomenon of a water hammer A. A. Surin, V. V. Cai, etc. are considered in work of the great scientist of N. E. of Zhukovsky and in works of other scientists. The water hammer is a consequence of emergence and movement of a hydraulic wave in the closed space of pipeline highways, in particular in a boring column when drilling prospecting wells by hydro drummers.

But the hydraulic wave results from a water hammer if at movement of a stream of liquid any obstacle to this movement is created. The obstacle can be full, movement of liquid stops or incomplete, movement of a stream doesn't stop, but the big resistance to this movement is created[4].



Hydraulic hammer

Fig. 3: Top adapter

In this section the task to consider movement of a hydraulic wave in a stream of the liquid moving in the pipeline is set is constant in one direction. In this case, from the boring pump to a well face. That is the stream moves to a face, and the hydraulic wave moves from a face to the mouth of a well and back.

It is clear to all that an important element, the hydro drummer, a source of all fluctuations here is. The valve of the hydro drummer is closed and there is a blow which through an adapter, through a pipe and a rock cutting element is transferred to a face where, there is rock destruction. Reverse motion is carried out at the expense of a spring, the valve is cut and goes up, and baizes continues a free wheeling and strikes blow. After blow of baizes under the influence of a spring starts moving up and the cycle is repeated.

Each cycle is accompanied by emergence of a hydraulic wave and a water hammer. The hydraulic wave after blow moves up to the pump and as the pump is the deadlock, is reflected down.

Earlier water hammer was considered as blow as force inducing us to consider this element of destruction and we didn't consider it as a hydraulic wave. But a hydraulic wave moving up and down on a column of metal pipes is influenced by locks, adapters, bends of pipes, etc. If to consider narrowing in locks and adapters, movement of a hydraulic wave are influenced by braking and will stretch on length. Practice of drilling showed that, length of a hydraulic wave starts changing with length approximately in 150-200 meters. At a depth of 150-200 m and more than a size of an increase starts changing from 5% to 100%.

Further at achievement of depth of 600-700 meters of a wave to be closed and there will be one long wave from the mouth to a face. But in the wave distribution of tension will be unevenly and somewhere it is more, somewhere it is less. Well and further intensity will be leveled and at a depth of 1000-1200 meters is leveled completely[4].

Theoretical researches of the reflected elastic waves of a resonance and resonance formation in the hydraulic oscillatory contour

The wave processes happening in system "a reflector - the hydro shock car", are described in works of Limanov E. L., Skobochkin B. E., Akhmetov E.A., Chekayev T. I., etc. But all these works describe wave processes at the established mode of a resonance. At the current stage of theoretical researches there is a need to consider wave processes in a hydraulic oscillatory contour that is in the second branch (a boring column) at development and formation of the reflected waves, to investigate process of formation of a resonance and imposing of the reflected hydraulic waves (impulses) at each other[5].

For convenience of calculations, we will accept the following assumptions:

(i) Pressure in the bringing highway (a boring column) remains to constants irrespective of the phenomena occurring in it;

(ii) Losses of pressure and speed of flushing liquid before closing of the valve are small, and they can be neglected;

(iii) Liquid movement in the highway is accepted one-dimensional, i.e. all local speeds are considered equal to average speed, pressure also is considered identical in all points of live section. Characteristics of this movement depend only on longitudinal coordinate;

(iv) It is obvious that if pressure in a boring column at the open valve remains to constants P_0-const, and the size of an elastic wave at the time of valve closing -ΔP_0, remains to a constant, that is ΔP_0-const.

(v) For carrying out calculations, it is necessary to enter into basic data concept of coefficients of reflection ($К_{refl.d}$) and ($К_{refl.p}$) reflection coefficient from the deadlock, coefficient reflections from the pump. These sizes independent of pressure and speed of a stream of flushing liquid in a boring column depend only on design data and quality of production of the hydroresonant camera and quality of the pump that is size constant. Reflection coefficients ($К_{refl.d}$) ($К_{refl.p}$), it in effect efficiency of a hydraulic oscillatory contour also represent the size which values more or are equal to zero and less unit[5].

$$0 \le К_{refl.d.} < 1 \quad \ldots(1)$$

$$0 \le К_{refl.p} < 1 \quad \ldots(2)$$

We considered reflector work, but work of a hydraulic oscillatory contour differs existence of the second branch and the device of the hydraulic resonant camera.

Considering work of a hydraulic oscillatory contour in single, initial time points $T = \frac{4l}{C}$ equal to one full cycle of operation of the car, we have constant pressure ΔP_0 and n-quantity of cycles. Then at n = 1, 2, 3 …. T = T1, T2, T3….

First stage

At instant closing of the valve of the hydro shock car over it additional pressure ΔP_0 is formed, then at n = 1, $P_1 = \Delta P_0$

The created hydraulic wave - ΔP_0 will perform work, that is moves car baizes which will strike blow to a hydro drummer anvil. This wave, extending up on the resonator, will reach the deadlock and will return to a car lock at the time of secondary closing (slamming) of the valve of the hydro drummer, but will return already taking into account losses in system or taking into account reflection coefficient, that is $\Delta P_0 К_{refl.d}$;

At the time of secondary closing of the valve over it pressure ΔP_0 was created again, then at прип = 2 $P_2 = \Delta P_0 + \Delta P_0 \cdot К_d$; Over the valve of the hydro shock car the hydraulic elastic wave in size equal $P_2 = \Delta P_0 + \Delta P_0 \cdot К_d$; this elastic wave extends and the following motion cycle of a wave to the deadlock and back to a car lock at the time of its following closing, but taking into account reflection coefficient begins,

$$P_3 = \Delta P_0 + (\Delta P_0 + \Delta P_0 К_{d.})К_{d.}$$

or $$P_3 = \Delta P_0 + \Delta P_0 К_{d.} + \Delta P_0 К^2_{d.}$$

further $P_4 = \Delta P_0 + \Delta P_0 K_{d.} + \Delta P_0 K^2_{d.} + \Delta P_0 K^3_{d.}$

further $P_5 = \Delta P_0 + \Delta P_0 K_{d.} + \Delta P_0 K^2_{d.} + \Delta P_0 K^3_{d.} + \Delta P_0 K^4_{d.}$

as → ∞ that we can write down N

$P_n = \Delta P_0 (1 + K_{d.} + K^2_{d.} + K^3_{d.} + K^4_{d.} + K^5_{d} + K^{n-1}_{d.})$

or $P_n = \Delta P_0 \sum_{m=0}^{n} K^m_{refl.}$ or $P_n = \Delta P_0 \frac{1 - K^n_{refl}}{1 - K_{refl}}$; or if n∞ $P_n = \Delta P_0 \xrightarrow{} \frac{1}{1 - K_{refl}}$

But our half of a hydraulic wave goes to a boring column and as the boring column is too a deadlock branch and there is a reflection of a hydraulic wave, but to a delay depending on well depth. We will take for an example 800-1000 m. At such depth the hydraulic resonant camera needs 5-7 cycles of work that the car would enter a resonance and worked steadily.

So the wave comes back from a boring column and over the valve pressure was created $P_n = \Delta P_0 \frac{1}{1 - K_{\text{refl}}}$ and we have to add to it pressure which comes from the pump.

Second stage

$$P_1 = \Delta P_0 \frac{1}{1 - Km} + \Delta P_0 K_p$$

This pressure affects the valve of the hydro drummer and spreads to the deadlock and back, but pressure comes to this moment from the pump taking into account coefficient from the deadlock pressure which comes from the pump.

$$P_2 = (\Delta P_0 \frac{1}{1 - Km} + \Delta P_0 K_p) + \Delta P_0 K^2_p K_d$$

$$P_2 = (\Delta P_0 \frac{1}{1 - Km} + \Delta P_0 K_p + \Delta P_0 K^2_p K_d)$$

Further $P_3 = (\Delta P_0 \frac{1}{1 - Km} + \Delta P_0 K_p + \Delta P_0 K^2_p K_d + \Delta P_0 K^3_p K^2_d)$

This pressure which developed over the hydro drummer valve, it moves to the deadlock and back

$$P_4 = (\Delta P_0 \frac{1}{1-Km} + \Delta P_0 K_p + \Delta P_0 K^2_p K_d + \Delta P_0 K^3_p K^2_d + \Delta P_0 K^4_p K^3_d)$$

Then the cycle is repeated and upto dynamic balance.

$$P_n = (\Delta P_0 \frac{1}{1-Km} + \Delta P_0 K_p + \Delta P_0 K^2_p K_d + \Delta P_0 K^3_p K^2_d + \Delta P_0 K^4_p K^3_d \ldots + \ldots \Delta P_0 K^{n-2}_p K^{n-1}_d)$$

$$P_n = \Delta P_0 \frac{1}{1-Km} + \Delta P_0 K_p + \Delta P_0 K_p K_d (K_p + K^2_p K_d + K^3_p K^2_d \cdots + \cdots K^{n-2}_p K^{n-1}_d)$$

$$P_n = \Delta P_0 \frac{1}{1-Km} + \Delta P_0 K_p + \Delta P_0 K_p K_d \sum_{m=0}^{n} K^m_p K^m_d$$

$$P_n = \Delta P_0 \frac{1}{1-Km} + \Delta P_0 K_н + \Delta P_0 K_н K_т \frac{1-KнKm}{1-KнKm}$$

As at $n \to \infty$ $K_p K_d \to 0$ that we can write down

$$P_n = \Delta P_0 \frac{1}{1-Km} + \Delta P_0 K_p + \Delta P_0 K_p K_d \frac{1}{1-KнKm}$$

Third stage

At the third stage, the wave created at the first stage comes, but comes back taking into account coefficient of losses in the pump.

$$P_1 = (\Delta P_0 \frac{1}{1-Km} + \Delta P_0 K_p + \Delta P_0 K_p K_d \frac{1}{1-KнKm}) + \Delta P_0 \frac{1}{1-Km} K_p$$

This stage is characteristic that that building of waves goes steadily.

$$P_2 = (\Delta P_0 \frac{1}{1-Km} + \Delta P_0 K_p + \Delta P_0 K_p K_d \frac{1}{1-KнKm} + \Delta P_0 \frac{1}{1-Km} K_p) + \Delta P_0 \frac{1}{1-Km} K^2_p K_d$$

$$P_2 = \Delta P_0 \frac{1}{1-Km} + \Delta P_0 K_p + \Delta P_0 K_p K_d \frac{1}{1-KнKm} + \Delta P_0 \frac{1}{1-Km} K_p + \Delta P_0 \frac{1}{1-Km} K^2_p K_d$$

$$P_3 = (\Delta P_0 \frac{1}{1-Km} + \Delta P_0 K_p + \Delta P_0 K_p K_d \frac{1}{1-KнKm} + \Delta P_0 \frac{1}{1-Km} K_p + \Delta P_0 \frac{1}{1-Km} K^2_p K_d) + \Delta P_0 \frac{1}{1-Km} K^3_p K^2_d$$

$$P_3 = \Delta P_0 \frac{1}{1-Km} + \Delta P_0 K_p + \Delta P_0 K_p K_d \frac{1}{1-K\textit{н}Km} + \Delta P_0 \frac{1}{1-Km} K_p + \Delta P_0 \frac{1}{1-Km} K^2{}_p K_d + \Delta P_0 \frac{1}{1-Km} K^3{}_p K^2{}_d$$

$$P_4 = (\Delta P_0 \frac{1}{1-Km} + \Delta P_0 K_p + \Delta P_0 K_p K_d \frac{1}{1-K\textit{н}Km} + \Delta P_0 \frac{1}{1-Km} K_p + \Delta P_0 \frac{1}{1-Km} K^2{}_p K_d + + \Delta P_0 \frac{1}{1-Km} K^3{}_p K^2{}_d) + \Delta P_0 \frac{1}{1-Km} K^4{}_p K^3{}_d$$

$$P_4 = \Delta P_0 \frac{1}{1-Km} + \Delta P_0 K_p + \Delta P_0 K_p K_d \frac{1}{1-K\textit{н}Km} + \Delta P_0 \frac{1}{1-Km} K_p + \Delta P_0 \frac{1}{1-Km} K^2{}_p K_d + + \Delta P_0 \frac{1}{1-Km} K^3{}_p K^2{}_d + \Delta P_0 \frac{1}{1-Km} K^4{}_p K^3{}_d$$

$$P_n = \Delta P_0 \frac{1}{1-Km} + \Delta P_0 K_p + \Delta P_0 K_p K_d \frac{1}{1-K\textit{н}Km} + \Delta P_0 \frac{1}{1-Km} K_p + \Delta P_0 \frac{1}{1-Km} K^2{}_p K_d + + \Delta P_0 \frac{1}{1-Km} K^3{}_p K^2{}_d + \Delta P_0 \frac{1}{1-Km} K^4{}_p K^3{}_d \cdots + \cdots \Delta P_0 \frac{1}{1-Km} K^{n-2}{}_p K^{n-1}{}_d$$

$$P_n = \Delta P_0 \frac{1}{1-Km} + \Delta P_0 K_p + \Delta P_0 K_p K_d \frac{1}{1-K\textit{н}Km} + \Delta P_0 \frac{1}{1-Km} K_p + \Delta P_0 \frac{1}{1-Km} K^2{}_p K_d (1 + K_p K_d + K^2{}_p K_d \cdots + \cdots K^{n-2}{}_p K^{n-1}{}_d)$$

$$P_n = \Delta P_0 \frac{1}{1-Km} + \Delta P_0 K_p + \Delta P_0 K_p K_d \frac{1}{1-K\textit{н}Km} + \Delta P_0 \frac{1}{1-Km} K_p + \Delta P_0 \frac{1}{1-Km} K_p K_d \frac{1}{1-K\textit{н}Km}$$

$$P_n = \Delta P_0 \frac{1}{1-Km} + \Delta P_0 K_p + \Delta P_0 K_p K_d \frac{1}{1-K\textit{н}Km} + \Delta P_0 \frac{1}{1-Km} K_p + \Delta P_0 \frac{1}{1-Km} K_p K_d \frac{1}{1-K\textit{н}Km}$$

$$P_n = \Delta P_0 \cdot \left(\frac{1}{1-Km} + K_p + \frac{1}{1-K\textit{н}Km} K_p K_d + \frac{1}{1-Km} K_p + \frac{1}{1-Km} K_p K_d \frac{1}{1-K\textit{н}Km} \right) \quad \ldots(3)$$

So, we received final pressure over the valve of the hydro shock car equal to $P_n$value, but can occurs both the fourth, and the fifth, and the sixth stage. Everything depends on well depth, the well is deeper the will be stages more and movement of wave processes is stabilized when strengthening of a wave will be equal to losses[5].

Condition of dynamic balance

In Fig. 3, the image of diagrams pressure is given when forming hydraulic elastic waves. At n = 1, it is shown diagram of pressure $P_0 + \Delta P_0$. This pressure is constantly formed over the hydro drummer valve in the reflector long resonator L.

As we consider a short period, means that before formation of pressure ΔP_0, except the constant pressure P, others reaches the deadlock of the hydro resonant camera and comes back to a lock at the time of secondary closing. In the course of movement of an elastic wave in system it shares and comes back to the car already taking into account coefficient of reflection or $\Delta P_0 \cdot K_т$. At secondary closing of the valve of the hydro shock car over it pressure ΔP_0 is formed and the reflected wave comes to this moment $\Delta P_0 \cdot K_т$ that is over the valve excessive pressure was created $(\Delta P_0+\Delta P_0 \cdot K_т)$. This pressure, extending, makes the following motion cycle and comes back from the dead lock of the hydro resonant camera at the following closing of the valve of the car, but the come-back reflected wave represents size excessive pressure was created $(\Delta P_0+\Delta P_0 \cdot K_т)+\Delta P_0 K_т$or $\Delta P_0+\Delta P_0 K_т+\Delta P_0 K^2_т$

Additional pressure over the car valve with each cycle of work will increase, balance yet won't be established. But then to the camera the wave from the pump comes and movement in the camera proceeds. Thanks to occurring process in system pressure in the reflected hydraulic wave in size is more, than pressure in previous but as process of imposing of shock impulses represents a meeting geometrical progression, the size of an increment of pressure of the reflected waves decreases and finally is stabilized, that is the condition is satisfied[6]:

$$\lim_{x \to \infty} K^n{}_p K^n{}_d = 0 \qquad \ldots(4)$$

The condition (13) should be designated as a condition of dynamic balance of system.

The condition of dynamic balance is a factor of stable work, thus the frequency of the hydro drummer corresponds to own frequency of the hydro resonant camera and the hydraulic oscillatory contour works in the established mode- a resonance.

Thus, theoretical calculation and diagrams of developments of hydraulic waves in system of a hydraulic oscillatory contour showed theoretical calculation how resonant waves and the received expression (4) are formed, is a necessary condition of stable work of system or a condition of dynamic balance of an operating mode of a hydraulic oscillatory contour and the hydro resonant camera[6].

CONCLUSION

(i) Hydro resonant camera's movements or processes, which are characterized by certain repeatability in time are called fluctuations. Oscillatory processes are widespread in the nature and equipment, for example swing of a pendulum of hours, alternating electric current,

(ii) In laboratory of hydro shock drilling of department of equipment of investigation of the Kazakh research institute of mineral raw materials, works on a reflector of hydraulic waves, in the seventeenth and the beginning the eightieth years,

(iii) But the hydraulic wave results from a water hammer if at movement of a stream of liquid any obstacle to this movement is created. The obstacle can be full, movement of liquid stops or incomplete, movement of a stream doesn't stop, but the big resistance to this movement is created,

Calculations we studded:

(i) Pressure in the bringing highway (a boring column) remains to constants irrespective of the phenomena occurring in it;

(ii) Losses of pressure and speed of flushing liquid before closing of the valve are small, and they can be neglected;

(iii) Liquid movement in the highway is accepted one-dimensional, i.e. all local speeds are considered equal to average speed, pressure also is considered identical in all points of live section. Characteristics of this movement depend only on longitudinal coordinate;

(iv) It is obvious that if pressure in a boring column at the open valve remains to constants P_0-const, and the size of an elastic wave at the time of valve closing -ΔP_0, remains to a constant, that is ΔP_0-const.

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