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Research Article

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Technology and Field Tests of Cement Slurry Treatment by Means of Electrical Hydropulse Device in the Initial Period of WOC

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ABSTRACT.
This article presents the features of the developed technology for cement slurry treatment by means of electrical hydropulse device during the initial period of WOC, as well as field tests of the said technology.The relevance of the problem under study is due to the lack of effective technology in the oil and gas industry, whereas the technology we have proposed allows significantly improving the quality of production casing strings cementing, and is easy to use, low cost, energy saving.Objective of the study is to justify the effectiveness of our technology in the current context.The leading approaches to the study of this problem are the research and designing methods which allow you to find the optimal result in the field of the said study.The article materials can be useful for engineering and scientific workers involved in the oil and gas wells drilling and cementing, as well as for postgraduate and graduate students who are engaged in research activities.

Keywords: drilling, oil wells, drilling mud, casing string, electrical hydropulse device, waiting on cement.

INTRODUCTION.

A number of scientists and researchers, including Bulatov A.I., KuznetsovYu.S, KuznetsovR.Yu., Arzhanov A.F., and others, have been involved in issues regarding the processing of cement slurry by means of different devices and whose works are considered to be interesting but in our view they need to be further elaborated and deepened. In view of this, the staff members of the Institute of Petroleum, Gas and Energy and the Institute of Basic Researchof FSBEI of Higher Education the Kuban State University of Technology, together with Yu.S. Kuznetsov and N.I. Kovyazin (Non-Linear Wave Mechanics Laboratory in the oil and gas complex of the branch of FSBI A. Blagonravov Institute of Mechanical Engineering of RAS (Russian Academy of Sciences) Scientific Centre of Nonlinear Wave Mechanics and Technology of RAS) developed the acoustic treatment of the cement slurry during the period of WOC and technical means for this [1].

MATERIALS AND METHODS

The essence of technology is as follows (Figure 1). The source of the acoustic signal moves inside the casing string according to the specified program and generates powerful pressure pulses that cause the elastic deformation of the pipe turning into the dying oscillations. To ensure the generation of the required pressure pulses with limited average power consumption due to the mass/volume characteristics of the radiation source and the capacity of power transmission channel, the pulse device implements the principle of energy accumulation over time with its subsequent radiation for a short period. In this case, it includes the frequency response match of the generated pressure pulse with the frequency oscillations of casing string itself.

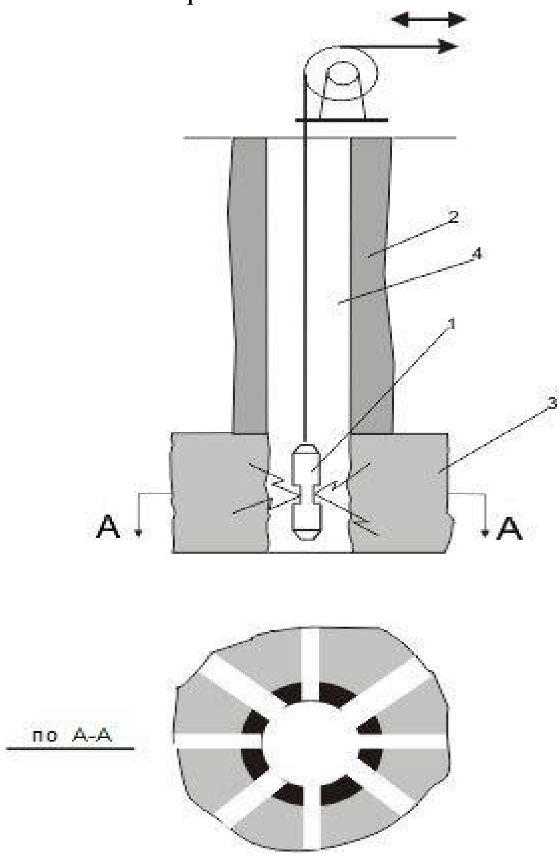

Figure 1 - Bottom-hole zone treatment schemeby means of electrical hydropulse device
1 - electricalhydropulse device; 2 - cement annular
3 - receiving formation; 4 - casing string

RESULTS.
The treatment program has been developed that ensures the achievement of maximum acoustic effect. This is achieved on the one hand by maintaining the pressure of cement slurry column and, on the other, by taking into account the time limit for optimum impact on the cement slurry in order to achieve the maximum value of the total radiated acoustic energy. The execution of the program begins with the lowering of the impact source and the cement slurry treatment from the top mark of its location behind the string to bottom hole. The device speed in this case, is set for maximum and should provide, on the one hand, the column pressure recovery within the entire range of the cement slurry location behind the casing string, and on the other, the time of the bottom hole achievement by the device when the coloumn pressure should not be lower than the formation one and the time of the impact application should remain optimal.When the source moving from the bottom hole, the "stepped" treatment is proposed to be done, each step of which is carried out in two stages. The first stage sets the minimum speed of the device providing the impact application within the upper limit of the optimum time. This allows obtaining the largest amount of acoustic energy emitted for these conditions. With such speed, the device moves to the mark above which the cement slurry gains the structure strength that reduces the column pressure below the set limit. From this mark, the second stage starts which is characterized with an increase in speed sufficient to restore the pressure of the cement slurry column. The interval of the device movement during the second stage is determined by the mark above of

which the time of the cement slurry pressure lowering to the specified level is sufficient for the device to achieve this mark and complete the first stage of the next treatment step.

The cycle described is repeated many times till the full treatment completion of the cement slurry gross interval behind string.

DISCUSSIONS.

The principle of the electropulsedownhole device operation,its design and specifications

As a source of acoustic effects for the implementation of technology, we have developed, together with the Institute of impulse processes and the technologies of the Academy of Sciences of Ukraine, the electrical hydropulsedownhole device.The operation principle of the electrical hydropulsedownhole device is based on the high voltage discharge which results in the creation of powerful shock waves spreading in the displacement fluid and applied to the casing string.The electrical hydropulse device (EHD) consists of the ground part represented by the frequency converter and the submersible part consisting of the charging unit, capacitive energy storage, arrester and electrode system. Structurally, the frequency converter consists of separate modules placed in the common body and interconnected by connectors. On the front panel of the body, the operating and monitoring controls are located. The submersible part of the device is made in the form of cylinder consisting of separate functionally finished modules connected with the frequency converter by a logging cable The feature of the electrode system is that it creates the electrical field with a high heterogeneity in the interelectrode area. This ensures the efficient operation of the electrical hydropulse devices in boreholes, at deeper depths, in comparison with the existing electrical hydropulse devices with the tip-shaped electrode system. To ensure the optimum environment of discharge, the fluids within the electrode system are separated from the displacement fluid by a sheath made of the acoustically "transparent" material.In the electrical hydropulse device, the multi-step electrical energy conversion to mechanical energy takes place during discharge. In the process of operation, the frequency converter 1 converts the mains voltage (220 V, 50 Hz) to a voltage of 800 V with frequency of 1 kHz. The converter voltage is supplied via the logging cable to the charging unit inlet of the device submersible part 2. Charging unit 2 increases and rectifies this voltage, providing the constant-current charge of the capacitive energy storage 3 connected to it. Upon reaching 30 kW on voltage storage unit, the arrester 4 breaks down and makes the connection of the energy storage unit 3 to electrode system 5. In this case, a conducting channel is formed between the electrodes culminating in the electric breakdown of the fluid after which all accumulated energy is introduced into this channel within a very short space of time. As a result, the fluid will have shock waves. Upon completion of the capacitors discharge process, the arrester restores high resistance and the next cycle of work starts.The technical characteristics of the electrical hydropulse device and its operation conditions are shown in the Table 1.

Table 1 - Technical characteristics and operation conditions of EHD

SL/ No.	Parameter name	Value
1	Mains voltage, V	220
2	Mains frequency, Hz	50
3	Power consumption (active), KW	2
4	Charging voltage of energy, kV	30
5	Energy storage capacity, ufd	
	- with two modules	1.6
	- with three modules	2.4
6	Energy accumulated in the energy storage unit, kJ	
	- with two modules	0.72
	- with three modules	1.08
7	Discharges frequency, Hz	
	- with two modules	0.4

	- with three modules	0.26
8	Dimensions of the device, m	
	- ground part (length × width × height)	0,4 × 0,3 × 0,25
	- submersible part (diameter × length with two modules)	0,1016 × 6,0
9	Mass of the submersible part of the device, kg	190
10	Device operating conditions	
	- diameter of the casing string, at least m	0.146
	- temperature of displacement fluid, not more than °C	80
	- hydrostatic pressure of displacement fluid, not more then, MPa	50

CONCLUSION.

Large-scale field tests of cement slurry treatment technologies with the help of electricalhydropulse device in the initial period of the WOC in the branch of Tyumenburgaz, the Drilling Company of GAZPROM JSC (now UrengoyBurenie of Gazprom Burenie Ltd).In this case, the following should be said.The effectiveness of the technology developed was assessed by comparing the quality coefficients of the production strings cementing on the experimental and conventional wells defined by CBL (Cement Bond Log) data according to the methodology set out in [2-4].

The methodology is based on the resulting formula for determining the quality coefficient of the casing string cementing:

$$K_{к} = \frac{0{,}9 \cdot \sum \square_{жс} + 0{,}5 \cdot \sum \square_{ч} + 0{,}2 \cdot \sum \square_{п}}{L}$$

,where $\sum \square_{жс}$, $\sum \square_{ч}$, $\sum \square_{п}$ is the sum of the cementing points with the hard, partial, and bad contact respectively.

In order to provide the similar conditions for cementing and geological section, the conventional wells on the same group of wells on which the experimental wells were drilled out have been taken for comparison.At the first phase, the developed technology was used for cementing the production strings with the cement slurry using two stage way and back pouring on the Yamsoveiskoe and Yubileinoe fields.Analysis of the technology application in the cementing the production strings and the results obtained allow saying the following:The cementing quality of strings has significantly improved, both in the case of the cement slurry and the lightweight cement slurry use □ 5-9 □.The average improvement in the quality of the production strings cementing with the cement slurry using two stage way and back pouring on the test wells in relation to the standard ones, was 1.43. This difference could be higher in the case of cement slurry treatment after back pouring at each test well. But, due to technical reasons, first and foremost because of the low reliability of EHD operation, this condition could not be met.The improvement in the quality of production strings cementing with the developed cement slurry at the Urengoy field was 1.55 and at the Zapolyarny field - 1.16.The lower results of technology use at the Zapolyarny field are due to the following reasons. First: due to the pressure test of production string immediately after the cementing for 30 minutes, the treatment time reduced by the same time respectively. Second: when EHD checking during maintenance it was established that the interelectrode gap in the arrester was 6 mm instead of 9-11 mm. In our opinion, the gap reduction occurred in the result of the spontaneous screwing out of one of the electrodes in the result of impact loads arising from discharge. This has led to the attenuation of hydrodynamical disturbances to the string during the cement slurry treatment.It should be noted that the increase in the quality coefficient of the cementing with the cement slurry in the interval of the string second stage (and during cementing in one step, in the interval of cementing with the cement slurry) is more noticeable in relation to the cementing quality coefficient improvement of the wells lower intervals.

In addition to this, it should be noted that the amount of calcium chloride injected into the grouting fluid was reduced during this technology application.

Difficulties encountered when implementing this technology:

(1) partial failure of cement float valve;

(2) insufficient reliability of the electrical hydropulse device;

(3) electrical conductivity effect of the displacement fluid on the discharge efficiency due to the fact that the developed electrode system was used at this stage without dividing sheath.

Thus, the pilot operation of developed technology on 41 wells showed the following. This technology allows improving significantly in the quality of production strings cementing, and is easy to use, low cost, energy saving. Its use does not change the existing cementing technology and does not increase in the time of wells construction, increases environmental safety during wells construction, and does not cause damage to the environment and subsoil.The economic effect of the technology developed is formed due to improvements in the quality of cementing that increases the time between repairs of wells.

RECOMMENDATIONS.

The article materials can be useful for engineering and scientific workers involved in the oil and gas wells drilling and cementing, as well as for postgraduate and graduate students who are engaged in research activities.

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