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CAVITATIONAL - PULSATING TECHNOLOGIES AS THE MEANS OF REDUCTION OF POWER CONSUMPTION DURING DRILLING OF A WELL

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Summary. Cavitational pulsation of fluid has been experimentally researched in turbulence chambers and the possibility of its use in order to increase the effectiveness of drilling of wells has been proved.

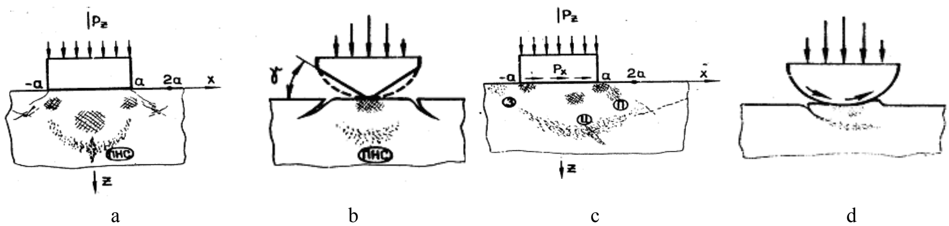
Key words: cavitation, drill bit, frequency, drilling rate.

INTRODUCTION

Drilling of wells includes a line of technological operations varying by their duration and energy inputs. Some of such operations are relatively steady and mainly depend on personnel qualification, while others depend on technologically conditioned failure of rock during the work of deepening of bottom hole.

OBJECTS AND PROBLEMS

In a work by B. Baydiuk [1] physical-mechanical evaluation of the processes of deepening of bottom hole of a well was generalized. From all the possible methods of deepening of a well the most widely known is mechanical crushing of the bottom hole by means of orderly coverage by a drill bit and removal of crushed and pre-crushed rock by a flow of drill mud. Main cracks are required to split large amounts of crushed rock at a time. The problem is that supplied power could be consumed only for forming of a new surface with the help of such cracks. Figure 1 (according to B. Baydiuk) shows the options of schematic conception of processes of crushing of rock by cutting structure of modern drilling bits both periodically repeated and in full contact with the rock which are obtained on the basis of analysis of various experimental data. According to the first scheme (Fig.1a) the shoving of an indenter forms an under edge border, whose lateral thrust causes the chipping of rock with formation of by-edge area of crushing. A variation of the first scheme is the shoving of an indenter, which has a working shape of semi sphere, cone or cut pyramid shape or a wedge.



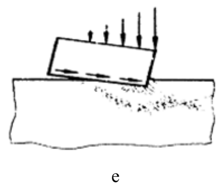


Fig.1. Generalized schemes of processes of effect on the rock made by the drilling elements of modern drill bits and particulars of means of crushing of the rock;
a.– vertical shoving of indenter with flat base;
b.– vertical shoving of indenter with flat base;
c. Complex (lateral) shoving of indenter into the formation with flat base (z- with initiation of rear break-away of the rock, c. – just forming of lower edge of break-away hole; p – point of initiation of breaking away of the rock)
d. – cutting = wear-out formation by indenter with spherical base
e – cutting of rock by front edge of the indenter

Fig. 1 above illustrates the scheme of crushing of rock when, besides vertical shoving, there is a lateral shifting of an indenter. According to the scheme 1b only a near- to- the- bottom part of the core remains as it occurs while drilling with diamond bits. Filtrate gets into the pre-crushed rock or drilling mud itself, which according to L.O. Shreind leads to an occurrence of cases of rock fragility.

During a single rock crushing act, only 8-12% of the directed energy is spent to create a crack. In order to completely reach the final depth 10-12% is required, and to chop off the console 6-8% is required of the total power. The remaining 68-76% of the power is spent on the crushing of a cut cone, elastic deformation of rock and chopped off particles, friction over surfaces etc. The largest part of the directed energy is the energy of resilient deformation of rock, which practically does not take part in the formation of volume of cuttings. Modern process of crushing of rock with a drilling bit from the power-saving point of view is very ineffective. One can reduce the power consumption only when the conditions are created for simultaneous crushing of the core and splitting console with the reduction of elasticity modulus of the rock in the area of crushing, reduction of deformations as well as effective break away of the rock within the borders of created cracks.

Crushing effectiveness is measured by mechanical drilling rate. Based on our analysis of well drilling in Prikarpatye region (1974, 1978, 1980) with the use of blow down of the bottom hole or froth inflow it was proved, that in relatively single-type rocks in drilling intervals from 100 m. to 2200m. the drilling rate would be 3-5 times higher, than the drilling rate with the use of drilling fluid for washout of the bottom hole. The reason of this was fast tearing off the pre-crushed rock from rock's monolith in the bottom hole of the well.

In the recent years in Ukraine and Russia a number of researches have been published with the use of pulsed and wave technologies in well drilling [2,3,4,5,6,7], when turbulence chambers were the source of pulsation and drilling fluid emitted gas bubbles while passing these chambers. In the process of leaving the chamber at the moment of passing confuser the bubbles split apart under external pressure. Lifetime of cavities and gas bubbles depends on fluid's impact pressure at the downstream of the turbulence chamber. Operation mode of vortex generator is based on the creation of circulating fluid flow (Fig.2). Nozzle's outlet is filled with annular flow only when the periphery and central (weight) part of the cross-section is filled with gas bubbles under pressure which is lower than atmospheric.

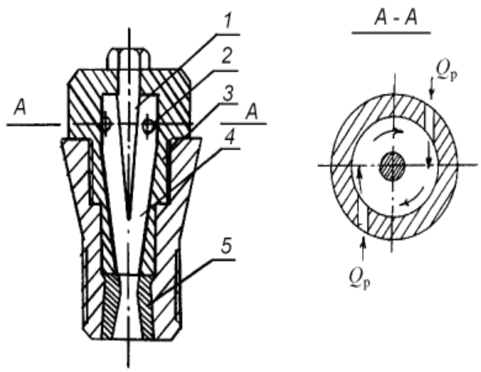


Fig. 2. The chart of hydrodynamic pulsator: 1- spire-bump stop 2 – fluid Entrance Ports, 3 -turbulence chamber head, 4 – turbulence chamber, 5- attachment

In 1977 in the USA there were published a number of researches claiming that during drilling tests drill bits with cavity chambers in test-bed conditions achieved better results than drilling with the use of jet nozzles.

In 2002-2007 at Ivano-Frankivsk National Technical Oil and Gas University we manufactured hydrodynamic pulsator (Fig.2) and experimental unit for pulse stream creation. In the process of researches pressure on the inlet of pulsator and on the outlet of pulsator was measured in independent mode using high pressure gages of Viatron Model 500 BPG Avv-200 type. Experimental researches proved that when process fluid goes through pulsator it creates pulsating flow with amplitude up to 6 Mpa and frequency from 1 to 20 Hz towards pressure decrease (Fig.3).

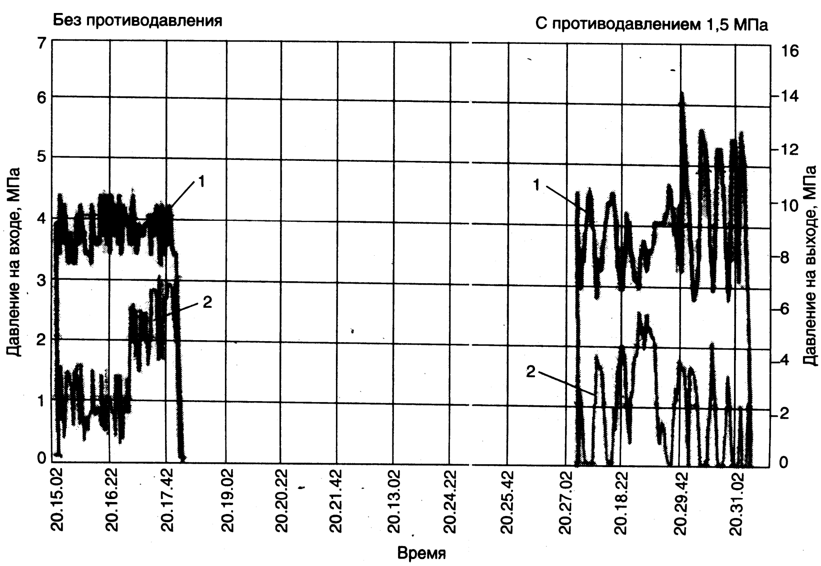


Fig. 3. Charts of pressure on an entrance and output of pulsation chamber

In order to check possibilities of cavity pulsation use there were manufactured three three-blade bits with turbulence chambers installed on them. Drilling bit wear showed, that penetration rate per drill bit had increased by 3-4 times and mechanical drilling rate was increased by 2,2 times. Further industrial tests indicated that internal surface of the turbulence chamber is destroyed under impact of bursting bubbles energy therefore researchers were advised to increase toughness of these chambers.

CONCLUSION

Increase of penetration rate per drill bit and drilling rate could be explained by reaching of drilling mud and filtrating into crevices. Split of the bubbles causes multiple instant pressure decrease in the well's bottom hole where rock gets torn off the rock monolith and moves upwards. An increase of drilling rate per bit and penetration rate per bit may result in the lowering of power consumption by almost two times.

REFERENCES

Baydiuk B., 1993: Physical-Mechanical Basis of Well Drilling Processes. - RJSC "Gaspprom". Gas Industry, series "Drilling of Gas and Gas Condensate Wells" – Moscow, 84. (in Russian)

Yaremiychuk R., Femyak Y., Vozniy V., 2008: Experimental Research of Energy of Pulsing Jets to Increase Effectiveness of Crushing of Rocks during Drilling. - Technologies of Oil and Gas, Newsletter of RAEN, Moscow. - .32-35 . (in Russian)

Ganiev R., Blinkov O., Ischchuk A., Anokhin K., 1999: Perspectives and Applications of Wave Generators to Iincrease penetration rate in drilling // problems of drilling rock crushing tools: Compilation of Reports of All Russian Scientific- Practical Symposium.- Samara SGTU. - 27-31 . (in Russian)

Ivannikov V., Ivannikov I., 2002: Cavitation and possibilities of application thereof at drilling, Rigging and Production from wells// Construction of Oil and Gas Wells Onshore and Offshore. – N 12. - 15-16. . (in Russian)

Yaremiychuk R., Femyak Y., Yakimenko Y., 2000: Crushing of Rocks during Cavitational Drilling of Wells. // Exploration and Development of Oil and Gas Fields. Series: Drilling of Oil & Gas Wells- Ivano Frankivs'k IFNTUOG. – №12. - 33-37. . (in Russian)

Panevnyk O., Yaremiychuk R., 1995: Development of Cavitaional Parameters of Jet Well Instruments //Exploration and Development of Oil and Gas Wells – №3. - 80-85. (in Russian)

ZASTOSOWANIE TECHNOLOGII KAWITACYJNO – PULSACYJNYCH W CELU REDUKCJI ZUŻYCIA MOCY PODCZAS WIERCENIA STUDNI

Streszczenie. Strumień kawitacyjny o przepływie pulsacyjnym zbadano eksperymentalnie w komorach turbulencyjnych i wykazano możliwości jego użycia dla zwiększenia efektywności wiercenia studni.

Słowa kluczowe: kawitacja, wiertło, częstotliwość, tempo wiercenia.