УДК.622.276.24; https://doi.org/10.37878/2708-0080/2022-2.09
https://orcid.org/0000-0001-6767-5713

ВЛИЯНИЕ ТЕМПЕРАТУРНОГО ФАКТОРА НА ВЕЛИЧИНУ ГИДРОСТАТИЧЕСКОГО ДАВЛЕНИЯ ПРИ БУРЕНИИ ГЕОТЕРМАЛЬНЫХ СКВАЖИН

С.А. МУСАЕВА,
докторант, *samira.musayeva@bhos.edu.az*

БАКИНСКАЯ ВЫСШАЯ ШКОЛА НЕФТИ
Азербайджан, AZ1025, г. Баку, Ходжалинский пр. 30

Одной из важнейших задач современного естествознания является энергосбережение и замена невозобновляемых источников энергии на ветровую, солнечную, геотермальную, волновую и другие виды энергии.

Главное преимущество горячей воды в том, что ее подачу можно получить в местах, где она непрерывно регенерируется и потребляет непосредственно тепло, энергию, еще важнее и полезная химия, обладает целебными свойствами и способностями.

В статье рассматривается влияния температурного фактора на величину гидростатического давления при бурении геотермальных скважин путем применения в процессе проводки глубоких скважин химических реагентов на основе водорастворимых полимеров, обеспечивающих стабильность буровых растворов при высоких температурах. Как уже было указано ранее, регулирование гидростатического давления путем повышения плотности бурового раствора в условиях высоких температур нецелесообразно. Поэтому необходимо провести меры по повышению седиментационной устойчивости буровых растворов.

КЛЮЧЕВЫЕ СЛОВА: *геотермальные скважины, буровой раствор, альтернативная энергетика, глубокие скважины, высокие температуры.*

ГЕОТЕРМАЛДЫҚ ҰҢҒЫМАЛАРДЫ БҰРҒЫЛАУ КЕЗІНДЕГІ ТЕМПЕРАТУРАЛЫҚ ФАКТОРДЫҢ ГИДРОСТАТИКАЛЫҚ ҚЫСЫМНЫҢ МӨЛШЕРІНЕ ӘСЕРІ

С.А. МУСАЕВА, докторант, *samira.musayeva@bhos.edu.az*

БАКУ ЖОҒАРЫ МҰНАЙ МЕКТЕБІ
Әзірбайжан, AZ1025, Баку қ., Ходжалинский даңғ. 30

Қазіргі жаратылыстанудың ең басты міндеттерінің бірі – энергияны үнемдеу мен жаңартылмайтын энергия көздерін жел, күн, геотермалды, толқын және тағыда басқа баламалы энергия көздерімен алмастыру.

Ыстық судың басты артықшылығы – ол үздіксіз регенерацияланатын және жылу мен энергияны тікелей тұтынатын орындарда беруге болатыны, оның емдік қасиеттері бар пайдалы химиясы одан да маңыздырақ.

Мақалада жоғары температурада бұрғылау ерітінділерінің тұрақтылығын қамтамасыз ететін суда еритін полимерлер негізіндегі химиялық реагенттерді терең ұңғымаларды бұрғылау үдерісінде қолдану арқылы геотермалдық ұңғымаларды бұрғылау кезіндегі температуралық фактордың гидростатикалық қысымның мөлшеріне әсері қарастырылады.

Жоғарыда айтылғандай, жоғары температура жағдайында гидростатикалық қысымды бұрғылау ерітіндісінің тығыздығын арттыру арқылы реттеу орынсыз болып келеді. Сондықтан бұрғылау ерітінділерінің седиментациялық тұрақтылығын жақсарту бойынша шаралар өткізілуі қажет.

***ТҮЙІНДІ СӨЗДЕР:** геотермалдық ұңғымалар, бұрғылау ерітіндісі, баламалы энергетика, терең ұңғымалар, жоғары температура.*

IMPACT OF THE TEMPERATURE FACTOR ON THE VALUE OF HYDROSTATIC PRESSURE AT DRILLING GEOTHERMAL WELLS

S.A. MUSAYEVA, Doctoral student, *samira.musayeva@bhos.edu.az*

BAKU HIGHER OIL SCHOOL
30, Khojaly Ave., Baku, AZ1025, Azerbaijan

One of the most important tasks of modern natural science is energy saving and replacement of non-renewable energy sources with wind, solar, geothermal, wave and other energies.

The main advantage of geothermal water is that it can be supplied in places where it is continuously regenerated and directly consumes heat, energy, more importantly, useful chemistry, has healing properties and abilities.

The article discusses the influence of the temperature factor on the value of hydrostatic pressure while drilling of geothermal wells using chemical reagents based on water-soluble polymers in the process of drilling deep wells, which ensure the stability of drilling fluids at high temperatures.As mentioned earlier, the regulation of hydrostatic pressure by increasing the drilling mud densityat high temperatures is inappropriate. Therefore, it is necessary to take measures to improve the sedimentation stability of drilling muds.

***KEY WORDS:** geothermal wells, drilling mud, alternative energy, deep wells, high temperatures.*

The development of geothermal power generation is associated with the construction of geothermal wells, reducing their cost and increasing the methods of productiveness.

Elaboration of optimum hydrodynamic and thermodynamic calculation methods, creation of thermohydrodynamic methods for hydrodynamic units can become one of the main directions in the thermal power development [1–4].

The use of magmathermal complexes for the geothermal power generation can be based on the circulation principle and meet the requirements of the subcritical thermodynamic conditions of the selected thermal carrier. Unfortunately, the full concept of closed-type geothermal circulating unit for supercritical cases has not yet been developed. This once again proves that further working outs are needed aimed at the effective implementation of geothermal energy through the construction of geothermal wells and the development of reserves of geothermal wells in the fields [5–7].

As is known, in practice, the hydrostatic pressure is measured by multiplying the drilling mud weight (measured in natural conditions) by the depth.

However, this does not take into account the fact that as a result of the combined impact of pressures and temperatures the drilling mud in the well changes its volume, and along with it, its density, i.e. due to the pressure, it constricts, and due to temperature, it expands.

Based on the condition of a linear increase in pressure and temperature with depth, the formula for calculating the hydrostatic pressure in the well can be represented as follows:

$$P = \gamma \cdot H \cdot \varepsilon \qquad (1)$$

where, $\varepsilon = \frac{2 - a\Gamma H}{2 - b\gamma H}$ – reduction coefficient; γ–well-head drilling mud weight, N/m^3; H – well depth; Г – geothermal gradient, $^\circ$C/m; a – coefficient of isobaric thermal expansion, 1/$^\circ$C; *b* – coefficient of isothermal compressibility by pressure, 1/Pa.

Figure 1 shows the pattern of change in hydrostatic pressure with depth based on formula (1) for real drilling conditions (γ = 1400N/m^3; a = $4 \cdot 10^{-4}$ 1/$^\circ$C; *b* = $4 \cdot 10^{-10}$1/Pa).

As can be seen from *Figure 1*, the value of the isothermal gradient has a significant impact on the hydrostatic pressure value on the well bottom (the dotted line shows the known dependence, according to which a and b are equal to zero). At the same time, as the well depth increases, the discrepancy in the results of hydrostatic pressure calculations increases, reaching 10 MPa or more in this case.

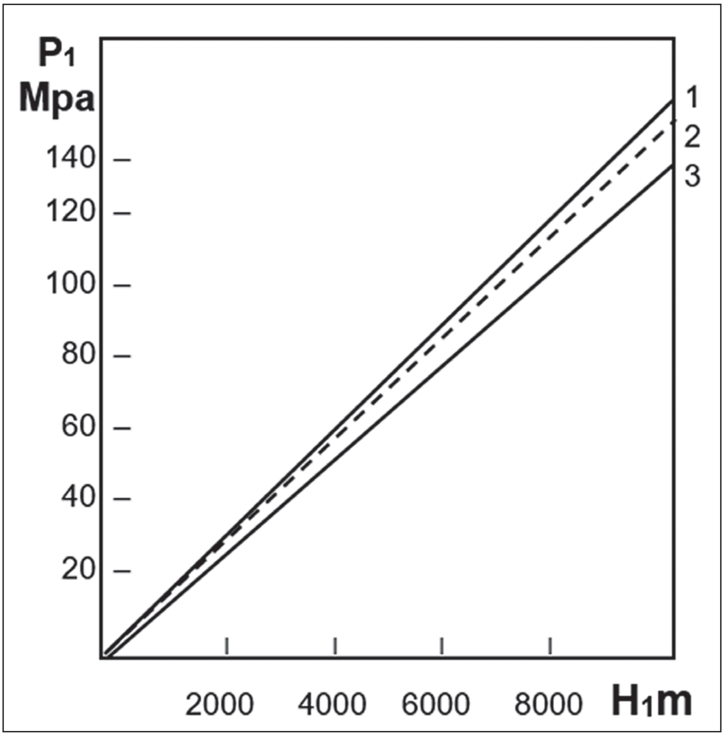

Figure 1 – **Dependence of the hydrostatic pressure in the well on the depth:**
1,2,3 – Г = 0; 0,02; 0,04 °C/m respectively

One of the most frequent types of complications in drilling deep wells is the flow of fluid of the formation (usually gas) after the drilling mud circulation is stopped. At the same time, the duration of the circulation absence in practice conditional of the duration of tripping operations, geophysical measurements, repair work, etc., can reach several days [8–10].

In this case, the main measure is some increase in the drilling mud density to achieve hydrostatic pressure up to the value of the total hydrodynamic pressure on the well bottom, at which there was no fluid inflow from the formation. As a rule, the drilling mud weighting does not give a positive result, and the fluid inflow from the formation into the well continues to occur after the circulation is stopped.

On the other hand, it is obvious that the fluid flows from the formation into the well due to some decrease in hydrostatic pressure. It is well known that the hydrostatic pressure value in the well is influenced by the value of the static shear stress of the drilling fluid, as well as the design of the well.

As already noted, the static shear stress (as well as the rheological parameters) of the drilling mud decreases significantly with increasing temperature. In this regard, the assumption that the decrease in hydrostatic pressure in a deep (high-temperature) well, and, consequently, the fluid inflow from the formation, occurs due to increased values of static shear stress, is unreasonable.

Moreover, a sharp decrease in static shear stress at high temperatures can be a major factor in lost circulation, formation hydraulic fracturing, and a violation of the sedimentation stability of the drilling mud in the well. For example, lignosulfonate drilling fluid with a density of 1.8 g/cm^3 and static shear stress for 1 and 10 minutes of rest, respectively, of 3.6 and 5.4 Pa at a temperature of 20 ^{o}C is stable. This can also explain the results of experiments performed on a special rotational viscometer (VSN-2M) depending on the temperature of the structural and mechanical properties of weighted drilling muds, which, as established, is parabolic in nature. At the same time, the fixed "thickening" of the drilling mud with high temperature (meaning the increasing branch of the parabola), interpreted in the literature only as a result of intensive dispersion of clay material, can be justified considering an additional factor – differentiated sedimentation of solid particles and, thus, the formation of viscometer of a gradually increasing and hardening annular plug. This interpretation of this dependence also substantiates the causes of hysteresis loops occurrence and partial reversibility of the structural and mechanical properties of drilling muds during cyclic temperature changes.

It is not difficult to calculate that the barite particles settling with a density of 4.2 g/cm^3 and a size of 250 μm in the drilling mud with a density of 1.8 g/cm^3 occurs at values of static shear stress at the initial rest time of less than 1 Pa. This means that at the wellhead (at wellhead temperature) this static shear stress value will increase at least 5-6 times. In addition, the static shear stress is usually measured after 1 and 10 minutes the drilling mud at rest, which is approximately 2–4 times higher than its similar value at the initial rest time.

Thus, to ensure the sedimentation stability of drilling muds in high-temperature wells, it becomes necessary to design and maintain very high values (about 10 Pa) of static shear stress on the surface. However, if the barite particle size is taken equal to 74 μm (corresponding to the established norm), then the static shear stress value per minute, which ensures the sedimentation stability of the drilling fluid, will become 3 Pa.

Example. During intermediate flushing of hydrostatic pressure in the well at 3700 m depth after the lifting and lowering of the drilling tool of well No. 8, pl. Zardob (bottomhole 4158 m, temperature 115°C) drilling mud density decreased from 1.98 to 1.46 g/cm^3. At the next stage of flushing, after the restoration of the initial density and the admission of the drilling tool directly to the bottomhole, there were no changes in the drilling mud density leaving the well. Similar phenomena are observed during the drilling of most deep wells in the exploration areas of Azerbaijan.

As mentioned earlier, the regulation of hydrostatic pressure by increasing the drilling mud density at high temperatures is inappropriate. Therefore, it is necessary to take measures to improve the sedimentation stability of drilling muds. One of the most realistic ways in this case is the widespread use in drilling deep wells of chemical reagents based on water-soluble polymers that ensure the stability of drilling muds at high temperatures, as well as powdered weighting agents that do not contain large particles in their composition and do not form when adding to the drilling mud of massive floccules.

CONCLUSION

1. To increase the production rate of geothermal wells, it is proposed to simultaneously drill multilateral geothermal wells based on the selected hydrodynamic parameters using the formulas of the Muscat-Bogewer theory.

2. Based on the analysis of field data, water sources and the concept of alternative energy development in the Republic of Azerbaijan were studied.

3. Upon the thermohydrodynamic studies, the method has been developed to prevent loss of drilling mud.

REFERENCES

1 Алхасов А.Б., Рамазанов М.М., Абасов Г.М. Использование геотермальной энергии в горячем водоснабжении // Водоснабжение и санитарная техника. – 1998. – №3. – С .24-25. [Alkhasov A.B. Ramazanov M.M. Abasov G.M. Ispolzovanie geotermalnoy enerqii v qoryachem vodosnabzhenii // Vodosnabzgenie i sanitarnaya tehnika. – 1998. – №3. – S. 24-25]

2 Алхасов А.Б. Возобновляемая энергетика. – М.: Физматлит, 2010. – С. 256. [Alkhasov A.B. Vozobnovlyaemaya energetika. – M.: Fizmatlit, 2010. – S. 256.]

3 Алхасов А.Б. Теплофизика и теплопередача в системах геотермальной энергетики / Дисс. д-ра техн. наук: 05.14.01., Махачкала, 2002. – С. 276. [Alkhasov A.B Teplophizika i teploperedacha v sistemah geotermalnoy energetiki // Diss. d-ra tehn. nauk: 05.14.01., Makhachkala, 2002. – S. 276]

4 Кулиев С.М., Есьман Б.И., Габузов Г.Г. Температурный режим бурящихся скважин. – М.: Недра, 1968. – С. 218. [Temperaturnyj rezhim buryashchihsya skvazhin. – M.: Nedra, 1968. – S. 218.]

5 Кутателадзе С.С. Основы теории теплообмена. – Л.: Машгаз, 1957. – С. 283. [Kutateladze S.S. Osnovy teorii teploobmena. – L.: Mashgaz, 1957. – S. 283.]

6 Лойцянский Л.Г. Механика жидкости и газа. – М.: Наука, 1973. – С. 848. [Lojcyanskij L.G. Mekhanika zhidkosti i gaza. – M.: Nauka, 1973. – S. 848.]

7 Мамаджанов У.Д. Динамическая характеристика промывочных растворов в бурении. – Л.: Недра, 1972. – С. 192. [Mamadzhanov U.D. Dinamicheskaya harakteristika promyvochnyh rastvorov v burenii. – L.: Nedra, 1972. – S. 192.]

8 Pilkington P.E. Facture gradients // Journal of petroleum engineer. – 1978. – May. – P. 138-148.

9 Toore Preston. How drill pipe can fe stripped back to bottom sucsessfully // Petrol and Petrohen. – 1992. – N 11. – P. 12.

10 Shlumberger. Log Interpretation Prinsiples/Applications. – Shlumberger publication, 1992.