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Research and development of combined universal cement mortar admixture

Rozwój badań nad scaloną uniwersalną domieszką do zaczynu cementowego

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ABSTRACT: Due to the wide variety of drilling and cementing conditions, different grades of cements for different conditions need to be produced by factories. Nowadays, with the development of test methods and techniques, additional materials and substances, the trend has been to focus on some basic cement (base), which, with various additional substances or materials, can be modified according to the conditions of use. According to the technology adopted in Schlumberger, two portions of cement slurry are mainly used for the entire length of the annulus "lead" and "tail" i.e. literally the "leader" (the first portion) and the "tail' (the second, last portion). Of course, the treatment of these portions with chemical reagents is different, and the first portion is several times larger in volume than the second portion. It is known that as a result of unsuccessful cementing, a gas-water-oil show may appear, leading to the removal of casing strings, fire, etc. As a result, this leads to the abandonment of the well. There is a time difference between the mixing of the first and subsequent portions of dry cement, especially the last ones, since while the subsequent portions of dry cement are just being mixed, the freshest ones have not yet been mixed at all, but the first portions are already finished; this portion of cement slurry in the well gradually begins to thicken under the influence of temperature and pressure. An effective reagent is needed. The optimal composition of the combined reagent should be considered as follows: CMC – 0.2%; FLS – 0.4%; Na_2CO_3 – 0.05%.

Key words: combined reagent, cementing, casing string, annulus, temperature, pressure, cement.

STRESZCZENIE: Ze względu na dużą różnorodność warunków wiercenia i cementowania, wcześniej w zakładach produkcyjnych starano się wytwarzać różne gatunki cementów, dostosowane do różnych warunków wiercenia. Obecnie, wraz z rozwojem metod i technik badawczych, jak również dodatkowych materiałów i substancji, trendem jest skoncentrowanie się na pewnym podstawowym cemencie (bazie), który za pomocą różnych dodatkowych substancji lub materiałów można modyfikować w zależności od warunków użytkowania. Zgodnie z technologią przyjętą w firmie Schlumberger stosuje się głównie dwie porcje zaczynu cementowego na całej długości przestrzeni pierścieniowej „prowadzącą" i „kończącą", czyli dosłownie „lead" – pierwsza porcja i „tail" – druga, ostatnia porcja. Oczywiście obróbka tych porcji odczynnikami chemicznymi jest inna, a pierwsza porcja ma kilkakrotnie większą objętość niż druga. Wiadomo, że w wyniku nieudanego cementowania może dojść do wycieku gazowo-wodno-ropnego, prowadzącego do usunięcia kolumny rur okładzinowych, pożaru itp., co w efekcie prowadzi do likwidacji odwiertu. Istnieje różnica czasu między mieszaniem pierwszej i kolejnych porcji suchego cementu, zwłaszcza tych ostatnich, podczas gdy kolejne porcje suchego cementu są mieszane, ostatnie nie są jeszcze w ogóle wymieszane, a pierwsze porcje są już przygotowane; zaczyn znajdujący się w otworze zaczyna stopniowo gęstnieć pod wpływem temperatury i ciśnienia. Potrzebny jest więc skuteczny odczynnik. Optymalny skład połączonego odczynnika należy rozważyć w następujący sposób: CMC – 0,2%; FLS – 0,4%; Na_2CO_3 – 0,05%.

Słowa kluczowe: odczynnik połączony, cementowanie, kolumna rur okładzinowych, przestrzeń pierścieniowa, temperatura, ciśnienie, cement.

Introduction

If one looks back chronologically, one can see that due to the wide variety of drilling and cementing conditions, various grades of cements needed to be produced at factories for different conditions (lightweight pumice, OCG, UCG-1, UCG-2, ShPTsS-120, ShPTsS-200, UShTs-1-120, UShTs-2-200, OShTs, TsTN, TsTPN etc.) (Bulatov, 1981; Dowell Schlumberger Publication, 1991; Appleby and Wilson, 1996). Nowadays, with the development of test methods and techniques, additional materials and substances, the trend has been to focus on some basic cement (base), which, with various additional substances

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or materials, can be modified according to the conditions of use. For example:

- general type cement;
- cold well cement;
- cement for "hot" wells.

An important property of general cement is its optimal thickening and hardening time at various temperatures and pressures. This is optimal since pump ability is maintained until the end of cementing, after which the most rapid thickening and curing can occur. This type of cement is suitable for use up to a depth of 2500 m. Its area of use can be easily extended with additional substances such as accelerators and retarders (Bittleston and Guillot, 1991, Bol et al., 1991). Its chemical composition and physical properties meet the requirements of type G cement when subjected to API testing. The low content of C_3A cement (2–3%) gives it good sulfate-resistant qualities (Burkhalter et al., 1984).

The general type cement test is performed according to specification:

- spread ability – 20 cm;
- specific surface 320 m^2/kg;
- temperature 220°C;
- start of setting – 6 hours 00;
- end of setting – 9 hours 00;
- bending strength (1 day) – 2.7 MPa;
- temperature 750°C;
- the beginning of setting – 1 hour 50 minutes;
- end of setting – 2 hours 20 minutes;
- bending strength (1 day) – 4.3 MPa.

Research materials and methods

API general type cements testing was carried on. Well depth is – 2440 m, surface temperature 270°C, bottom temperature 520°C and, pressure – 35 MPa. Estimated injection time to the bottom is – 28 min, the water-cement ratio – 0.44. Under these conditions, the thickening time was 90 min, water separation – 0.5 cm^3 (Catala et al., 1991; Dowell Schlumberger Publication, 1999).

At a depth of 3660 m, the initial temperature is 270°C and the final temperature is 800°C; the pressure is 70 MPa and the pumping time to the bottom is 44 minutes. With the use of the moderator, the thickening time was 155 minutes.

Strength parameters (in compression) under various conditions:

- 350°C / 5.5 MPa, after 8 hours – 4.4 MPa;
- 600°C / 20.6 MPa, after 8 hours – 14.6 MPa.

Cement for "cold" wells. It has a high C_3S content (50–55%), and a low C_3A content (2–3%), and good sulfate resistance. It contains gypsum and additional materials, which, with the help of fine adjustment, can still modify the properties of the cement in the desired direction.

Cement for "hot" wells. For downhole conditions of the order of 1000°C and above, the temperature, pressure of the order of 100 MPa and above, it becomes difficult to modify something with the help of normal cement of a general type. For example, thickening is accelerated to such an extent that it becomes impossible to control it with retarding additives only. Chemically cement for "hot" wells meet the requirements for sulfate resistance and the content of C_3A is (2–3%) (Dowell Schlumberger Publication, 1995; Novruzova and Qadashova, 2020).

According to the technology adopted in Schlumberger (Burkhalter et al., 1984; Bol et al., 1991; Bittleston and Guillot, 1991; Dowell Schlumberger Publication, 1991; Appleby and Wilson, 1996,), two portions of cement slurry are mainly used for the entire length of the annulus "lead" and "tail" – i.e., literally the "leader" (the first portion) and the "tail" (the second, last portion) (Ishchenko, 1977). Of course, the treatment of these portions with chemical reagents is different, and the first portion is several times larger in volume than the second portion. Typically, the last portion, which secures the casing shoe, is made from pure Portland cement with the highest possible stone strength; the first portion is made with adjustable parameters depending on the conditions of the casing cementing (Peslyak, 1973; Ishchenko and Selvashchuk, 1977).

It should be noted that the following reagents are used for cementing 13 3/8 and an intermediate casing in the Chirag area:

- antifoam – antifoam;
- liquid extender – stretch liquid;
- retarded – retarder;
- dispersing – dispersant.

Work results

It is known that as a result of unsuccessful cementing, a gas-water-oil show may appear, leading to the removal of casing strings, fire etc. As a result, this leads to the abandonment of the well. The technology of cementing casing strings in one step, existing in Azerbaijan, has disadvantages due to not taking into account a number of factors that impede the control of the process of cement slurry thickening in the well, which is especially necessary when there is a danger of gas-water-oil appears (Danyushevsky and Dzhabarov, 1978). There is a time difference between the mixing of the first and subsequent portions of dry cement, especially the last ones, since while the subsequent portions of dry cement are just being mixed, the freshest ones have not yet been mixed at all; the first portions

Table 1. The effect of a combined universal additive from CMC. FLS and soda ash on the performance of cement mortars and stones
Tabela 1. Wpływ połączonego uniwersalnego dodatku CMC. FLS i sody kalcynowanej na właściwości użytkowe zaczynów cementowych i kamieni

No.	Type of cement	Additive [%]			W/C	Density [kg/m^3]	Fluidity [cm]	Setting time at 750°C [h-m]		Water-settlement after 2 h [%]	Water loss [cm^3]		Daily strength 750°C [MPa]	
		CMC	FLS	Na_2CO_3				start	end		1 min	30 min	bend	compression
1.	Portland cement GOST 1581-96 Karadagplant	–	–	–	0.50	1820	23	2-05	3-00	2.0	55	67	3.8	8.6
		0.05	0.1	0.01	0.50	1820	24	2-40	4-05	1.5	50	63	3.7	8.3
		0.20	0.4	0.05	0.50	1820	24	3-10	4-30	1.3	43	52	3.6	8.1
		0.40	0.8	0.10	0.50	1820	24	3-45	4-50	1.0	38	49	3.6	8.2
		0.20	–	–	0.50	1820	20	2-35	3-20	1.0	43	53	3.7	8.2
		–	0.4	–	0.50	1810	25	3-00	4-15	1.2	45	55	3.7	8.3
		–	–	0.05	0.50	1820	23	2-00	3-00	1.5	53	65	3.7	8.3
2.	Cement by API standards. class G	–	–	–	0.44	1890	21	1-50	2-45	1.4	38	46	10.1	19.8
		0.05	0.1	0.01	0.44	1890	22	2-10	3-05	1.2	35	42	9.8	19.4
		0.20	0.4	0.05	0.44	1890	22	2-30	3-35	1.0	33	40	9.7	19.3
		0.40	0.8	0.10	0.44	1890	22	3-15	4-05	0.8	29	37	9.5	19.2
		0.20	–	–	0.44	1890	19	2-25	3-20	0.8	30	37	9.5	19.2
		–	0.4	–	0.44	1880	24	2-30	3-30	1.0	31	39	9.5	19.0
		–	–	0.05	0.44	1890	21	2-00	2-50	1.3	36	43	9.7	19.1
3.	Portland cement GOST 1581-96 Karadagplant	–	–	–	0.35	2120	20	2-35	3-50	2.0	29	38	2.1	3.9
		0.05	0.1	0.01	0.35	2120	20	2-45	4-10	1.0	16	24	2.0	3.8
		0.20	0.4	0.05	0.35	2120	20	3-15	4-25	1.0	16	20	1.8	3.6
		0.40	0.8	0.10	0.35	2120	20	3-55	5-10	1.0	10	20	1.7	3.4
		0.20	–	–	0.35	2120	18	2-50	4-00	1.0	12	20	1.8	3.5
		–	0.4	–	0.35	2120	22	3-10	4-10	2.0	13	24	1.8	3.5
			–	0.05	0.35	2120	19	2-50	3-55	1.5	25	35	1.8	3.5

are already finished, this portion of cement slurryin the well gradually begins to thicken under the influence of temperature and pressure. In addition, additives to the cement slurry are of no small importance, and in this case, the most desirable additives enhance the stability of the cement slurry, reducing water loss without causing the mortar to foam (Mochernyuk, 1972, Bulatov, 1976).

Scope of results

With the usual addition of lignosulfonate reagents to cement slurries, in order to regulate (increase) the thickening time, foaming occurs. This causes deterioration in the main parameters of cement slurry and stone, leading to instability in the operation of cementing pumps, perhaps causing complications in the well, etc. In addition, these reagents cause sedimentation instability (Rakhimbaev and Karimov, 1978; Suleymanov, 2012a, 2012b). To almost completely prevent foaming while mixing cement mortar and significantly reduce water loss while increasing sedimentation stability and plugging properties, a combined universal additive has been developed as a retarder agent, consisting of carboxymethyl cellulose, ferrolignosulfonate and soda ash (the latter should be used with heavy cement mortars, Table 1) (Suleymanov, 2012c).

Conclusions

The novelty of this article is as follows: as a result of unsuccessful cementing, a gas-water-oil appear is known to occur, leading to the removal of casing strings, fire etc., as a result, this leads to the abandonment of the well. There is a difference in time between the mixing of the first and subsequent

portions of dry cement, especially the last ones, since while the subsequent portions of dry cement are just being mixed, the freshest ones have not yet been mixed at all; the first portions are already finished, this portion of cement slurry in the well gradually begins to thicken under the influence of temperature and pressure. Therefore, an effective reagent has been developed and the following should be considered the optimal composition of this combined reagent: CMC – 0.2%; FLS – 0.4%; Na_2CO_3 – 0.05%.

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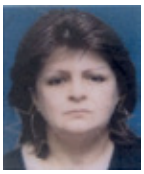

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