P213 APPLICATION OF GEL-FORMING COMPOSITIONS FOR ENHANCED OIL RECOVERY

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It is established that an increase of oil viscosity and heterogeneity of porous medium results in drastic decrease of recovery factor. Heterogeneity of porous medium causes irregularity of displacement front and at the same time water drive of high-viscosity oil is accompanied by viscosity instability even in the uniform reservoirs.

The application of polymers decreases the influence of the abovementioned factors. Small addition of polymers of high molecular weight results in drastic decrease of water mobility. Displacement of oil by the agent having high viscosity results in levelling of displacement front in the heterogeneous reservoirs providing an increase of the reservoir sweep efficiency (1).

With high permeability heterogeneity the efficiency of the polymer application decreases because of decrease of the flow resistance factor and residual flow resistance factor. In this case the cross-linking polymer systems (CPS) are used. Addition of the gel-forming systems into polymer solution results in gel formation, besides viscosity of solution and residual flow resistance factor increase. On the whole the salts of polyvalent metals are used as cross-linking agents (2).

The application of the polymer-dispersion systems (PDS) is another way for increasing the efficiency of polymer flooding (3). The clay particles having larger specific surface effectively adsorb polymers forming floccula. In this case the effect shows itself when they are commensurable with the size of pore channels. The size of floccula depends on the size of pore channels and molecular weight of polymer. The use of the technology is limited by the optimum pore size (4-5 mcm) and rapid decrease of residual flow resistance factor because of rapid PDS breakdown in porous medium.

Further search in the field of the development of the new polymer technologies resulted in the development of the gel-forming systems (GFS). In this case chrome-potassium alum adsorbed on the clay particles is used as cross-linking agent (4).

It was established on the basis of pattern study that GFS injection results in greater decrease of the fluid filtration rate in porous medium as compared with GFS and PDS. (Fig.1). It is caused by formation of the volumetric and stable in time structurized system in porous medium. GFS application provides maximum decrease of the filtration rate and prolonged resistance to washout, residual flow resistance factor is 1.5-2 times as much as that for PDS and GFS under the comparable conditions. The advantages of the method also are: ecological safety and use of the available technological assembly for its realization.

The technology (5) has been used in block 1 of Kholmov area of Romashkino oil field. The basic working object of the block are terrigenous deposits of Upper Devonian. The reservoirs involve fine-grained sandstones and coarse siltstones. Average permeability 0.38 mcm^2 , porosity 0.19 and initial oil saturation 0.792. Viscosity of oil varies from 2.9 up to 9.9 mPa s under the formation conditions. The well production rate ranges from 3-5 t/day to 50 t/day. Elastic water drive. According to chemical composition formation water is chloride-sodium, high salinity, with considerable calcium content. Total salinity ranges from 228 g/l to 274 g/l. 98 producing wells and 29 injection wells.

The ratio of producing and injection wells is 3.3. The basic characteristics of block 1 development during the last years are listed in Table 1.

Table 1

Development of block 1 of Kholmov area

Characteristics of development	Unit	Years			
		1993	1994	1995	1996
Oil production	thousand tons	90,0	80,0	67,7	76,0
Fluid production	thousand m^3	372	363	196	380
Water content	% weight	75,8	78,0	77,1	80,0
Recovered amount from IRR	%	67,6	68,4	69,1	69,9
Rate of recovery from IRR	%	2,7	2,5	2,2	2,5

Maximum oil was recovered in 1983, in this period the rate of recovery from initial recoverable reserves (IRR) amounted 5.67%. Then oil production slowly decreased. Peculiarity of the block development is the low efficiency of oil displacement, the injection volume is 2-3 times as much as the volume of produced fluids. It is connected with reservoir mudding off. The object in using the technology is the reduction of the injection well injectivity and increase of the reservoir sweep efficiency.

The use of the technology was initiated in the middle of 1995. The map of residual oil density for a moment of the technology application is shown in Fig.2. Water content of produced fluids averaged 78%, 68.7% of recoverable reserves was produced.

The technology involves the successive-alternate injection of 0.5-0.1% of polymer solution and 3-7% of modified clay solution. Originally 1000m³ of technological fluids was projected to be injected per a well but the injection volume was limited by an increase of injection pressure which must not be higher than 0.85. The actual injection volume ranged from 200 to 860 m³.

Table 2

Characteristics of technology DNPCH-1 application

No of well	Date of injection	Volume of injection, m ³	Injectivity before injection m ³ /atm	Injectivity after injection m ³ /atm
13044	08.95	600	190/100	185/130
13111	09.95	500	300/100	250/120
13047	10.95	200	260/110	200/130
13105	10.95	860	300/80	250/120
13043	11.95	200	200/130	160/140
13211	07.96	560	300/120	280/140
13025	07.96	780	290/110	250/140

According to the results of the oil-field tests the injectivity index in 7 treated wells decreased on the average from 2.66 to 1.57m³/s atm or to 59% from original one (Table 2). The treatment took effect in 16 producing wells. The effect showed itself in the area by the stabilization of water content of produced fluids (Fig.3). Current increase of the oil production rate in the wells ranged from 0.2 to 3.3 t/day and averaged 0.7 t/day.

The application of the technology in block 1 of Kholmov area for 21 months after the beginning of the application resulted in production of 4501 t of additional oil. The specific efficiency is 1.2 t of oil per 1m³ of technological fluid, according to the calculation the application of the technology is economic when the specific efficiency is 1 t/m³. Monitoring of the block operation continues.

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Variation of polymer system mobility in porous medium by using different technologies

Fig. 1

Residual recoverable reserves of the pilot area at the beginning of the method application

Fig.2

Development factors (water content)

Fig.3