The 2017 World Congress on
Advances in Structural Engineering and Mechanics (ASEM17)
28 August - 1 September, 2017, Ilsan(Seoul), Korea

Experience analysis and evaluation of the effectiveness of steam injection technology

D.A. Akhmetov

Oil Production Department of JSC "Karazhanbasmunay", Aktau, Kazakhstan
aldee@list.ru

ABSTRACT

The production, transport to the collection points, preparation and, finally, refining of heavy oil is one of the urgent problems of the oil industry. Canada, Venezuela, Mexico, the United States, Kuwait, China are the countries with large reserves of heavy oil. On the basis of the experience gained in Brazil, it is clear that self-sufficiency has been already reached in oil production in Brazil, however it is necessary that improved oil recovery technologies be continually studied to maintain the current production or to increase it. Rio Grande do Norte (a Brazilian State) comprises many heavy oil reserves and the exploration activities in the Brazilian Basins of Campos, Santos and Espirito Santo have led to the discovery of large amounts of heavy oils. Russia has significant resources of heavy oil, the volume of which is about 55% of total Russian oil reserves, ie more than half. Kazakh deposits also contain heavy oils (the North Kenkiyak, Karazhanbas). Heavy oil in Middle East fractured carbonate reservoirs account for 25-30% of the total oil in place in the region. Production of heavy oil from such reservoirs is thought to play an important role in the future of the ever-growing world's energy consumption. In this regard, we have made a comprehensive analysis on the example of one of the objects of Karazhanbas field. Steam injection was applied at this object. A calculation to determine the required amount of steam for injection have been performed and wells, where it is necessary to optimize fluid production level for proper distribution of the cells, have been selected. It is shown that if the potential flow rate is higher than the actual flow rate and the percentage of compensation for pumping is more than 100, it is possible to suggest optimization of wells corresponding to these criteria. If the potential flow rate is lower than the actual flow rate, and the percentage of compensation for pumping is below 90, then an increase in steam consumption with increasing of bottom-hole pressure of fluid injection wells can be offered.

1. INTRODUCTION

In many industrialized countries of the world, the heavy oil is seen as the main base for the development of oil production in the coming years. In the world there are

countries that distinguished by huge reserves of heavy oil. At the same time Canada, Venezuela, Mexico, the United States, Kuwait, China have the largest reserves of high viscosity heavy oil. Russia also has significant resources of hard-to-recover oil, the volume of which is about 55% of total Russian oil reserves, scilicet more than half. Russian heavy oil deposits are mainly located in the Perm region, Tatarstan, Bashkiria and Udmurtia. The largest of them: Van-Eganskoye, North-Komsomolsk, Usinsk, Russkoe, Gremikhinskoye, etc., wherein more than 2/3 of all stocks of highly viscous oil are located at depths of up to 2000m.

The paper (Barillas, 2008) presents an overview of various studies on the enhanced recovery of heavy oil. On the basis of the experience gained in Brazil, the authors note that self-sufficiency has been already reached in oil production in Brazil, however it is necessary that improved oil recovery technologies be continually studied to maintain the current production or to increase it. Rio Grande do Norte (a Brazilian State) comprises many heavy oil reserves and the exploration activities in the Brazilian Basins of Campos, Santos and Espirito Santo have led to the discovery of large amounts of heavy oils. It is possible to increase heavy oil recovery in some of these reservoirs with the help of improved oil recovery processes, thus enhancing oil field productivity and profitability.

Thermal oil recovery methods are used mainly in heavy oils or bituminous sands with the intention of reducing oil viscosity in the reservoir, increasing its mobility and allowing better displacement to the producing wells. The selected process always depends on reservoir characteristics, reservoir fluids, area and experience from similar reservoirs. Due to its complexity, numerical analyses, reservoir modeling and profitability analyses are always required in order to determine which process is more efficient in minimizing the amount of injected fluids. In thermal methods two categories can be considered: in situ combustion, whereby heat is generated inside the reservoir, starting with the combustion of part of the oil found in the reservoir and injection of heated-up fluids, whereby heat is generated at the surface and transferred to the reservoir through a fluid injected into the well. In the injection of heated-up fluids, water is used as a medium of heat transfer from the surface to the oil zone. Water can be injected as steam or still in the liquid state at very high temperatures. Therefore, two main processes are to be considered: steam injection and hot water injection.

The in situ Combustion method begins with the injection of heated air into the oil reservoir. Heat is generated as a result of oil oxidation, increasing the temperature. Continuing the oxidation, the temperature eventually reaches the so-called "ignition point", when the combustion is established. At that point it is necessary to inject cold air to provide continuity to the process (Briggs 1987, Thomas 2001). The injection of steam as a recovery method for heavy oil has been used for many years in the United States, Canada, Brazil and Venezuela. In this process steam is continuously injected in one or more vertical wells, and the oil is pushed away to producing wells.

Cyclical stimulation (also known as huff n' puff) was accidentally discovered in Eastern Venezuela in 1959 (Nasr, 2005). In this process, steam is injected under high pressure and temperature. The high injection pressure dilates or fractures the reservoir rock and the high temperature helps to reduce oil viscosity. Steam-assisted gravity drainage (SAGD) and its variations are technologies that have been recently considered as more effective in the recovery of heavy oil and bituminous sands. The

method involves two horizontal parallel wells vertically separated by a short distance, where the top well serves as steam injector and the bottom well picks up reservoir water, condensed water and heated oil. Gravity is the acting force in this process. When steam is continually injected at the top well, oil is heated up and forms a steam chamber that grows up and towards the surroundings (Butler, 1991). The temperature inside the steam chamber becomes essentially equal to the temperature of the injected steam.

Expanding solvent (ES-SAGD) is a combination of solvent and steam injection that take advantage of the benefits from the heat provided by steam and the miscibility offered by the solvent. This is a novel process that has already been tested in oil fields, resulting in improvement of oil rate production and steam oil ratio (SOR). This process requires less energy than conventional SAGD.

Heavy oil in Middle East fractured carbonate reservoirs account for 25-30% of the total oil in place in the region. Production of heavy oil from such reservoirs is thought to play an important role in the future of the ever-growing world\'s energy consumption in which Iran's recoverable heavy oil is more than 85 billion barrels (Ghoodjani, 2011). As is mentioned in (Ghoodjani, 2011), the offshore Ferdows field in Iran is reportedly on the order of 30 billion barrels of oil and holds perhaps the greatest promise to add significant future carbonate heavy oil production within the region. With depletion of conventional petroleum reserves and increase of hydrocarbon fuel demand, there is no doubt that there will be a tremendous demand on the development of heavy oil reservoirs in the coming decades. As most of the oil is stored in matrix due to its higher storage capacity than fracture network, reservoir development plans will aim at maximizing the matrix oil recovery. For reservoirs with high recovery factor, minimizing matrix residual oil saturation is a critical issue to extend the life of the reservoir. For reservoirs with low recovery factor, accelerating the production rate is more vital. For each of these reservoir types, different Enhanced Oil Recovery (EOR) methods should be considered and implemented accordingly. In study (Ghoodjani, 2011) a comprehensive review is conducted to figure out the feasibility of heavy oil recovery from fractured carbonate reservoirs by use of Cyclic Steam Stimulation (CSS), Steam injection, In-Situ Combustion (ISC), Steam Assisted Gravity Drainage (SAGD), Vapor Extraction (VAPEX) and Expanding Solvent-Steam Assisted Gravity Drainage (ES-SAGD).

Kazakhstan oilfields are also distinguished by hard-to-recover heavy oil (Turkov 2014, Analysis of the effectiveness …, Zhao 2013, Esetov 2016). In paper (Zhao, 2013) presents an integrated study on the superheated steam injection in the North Kenkiyak Field, Kazakhstan. The methodologies cover investigation of mechanisms of superheated steam in recovery, lab experiment, and numerical simulation. The study indicates that the injection of superheated steam can cause rock wettability conversion which is favorable to recovery.

The higher the heat enthalpy, the larger the specific volume and latent heat of vaporization of superheated steam would result in the better production and economic performance. The study result was further conformed in the pilot test. Field fulfillment is optimized and scheduled. The oil of Karazhanbas is heavy (ρ = 0.936) and highly resinous oil (up 24%), according to its composition. The output of light fractions is about 30%, at the boiling point of up to 300-350°C. The vanadium content - 250-300g/t. The

viscosity of the reservoir oil ranges from 160 to 500 mPa.s, so from the beginning of development of the Karazhanbas, oilfield have been applied design solutions, whereby thermal methods have been used, where the main one is steam injection(oil recovery efficiency(ORE) - 86.3%) (Turkov 2014, Esetov 2016). Paper (Esetov, 2016) investigates the Karazhanbas oilfield, according to the development condition and with application of impact thermal methods on layer. For this purpose, simultaneous application of thermal-steam cyclic wells processing are utilized. At the first step, geological structure data are provided on new wells. Then various indexes such as in homogeneity, filtration and capacitor properties of layer-collectors, physical and chemical properties analysis and petroleum composition are evaluated. The statistical analysis on wells processing is conducted and the main factors which has the most effects are specified. On the basis of the analysis, the optimum mode of carrying out thermal-steam well processing (TSWP) is determined. Results demonstrate that productions with water content are optimal. Finally technological and economic effects of carrying out processing are proposed. The payback period of TSWP costs is about 1 year, in other words, the extra initial costs are covered over a year.

Typically, the viscosity of oil with increasing temperature particularly in the range of 20-80°C is sharply reduced. Since the oil flow rate is inversely proportional to its viscosity, the well productivity can be increased 10-30 times or more. It is known that high-viscosity oil with high density have a greater viscosity reduction rate, their residual oil saturation decreases more sharply, especially at temperatures up to 150 ° C. With increasing temperature, the oil viscosity decreases more rapidly than the viscosity of water, which is also conducive to enhanced oil recovery (Steam injection …, proofoil.ru/Oilproduction/Steamaction.html). Reserves of such types of crude oil are not less than $ 1 trillion tons (Heavy oil production, www.to-inform.ru/index.php/arkhiv/item/добыча-тяжёлой-высоковязкой-нефти, 2010), which is more than five times the volume of remaining recoverable oil reserves of low and medium viscosity. Production of the heavy oil, its transportation to the collection points, and the preparation, finally, processes to obtain the final products - one of the urgent problems of the oil industry.

2. FORMULATION OF THE PROBLEM

As it is known, during injection of steam is formed three zones: a first zone with approximately the same temperature, saturated by steam, whose temperature depends on the pressure in the zone. The second zone - the zone of hot condensate (water), in which the temperature decreases from the saturated steam temperature to initial formation. The third zone - an area not covered by the thermal effect, with the formation temperature. Due to the heat consumption, contained in the thermal fluid, for heating the reservoir and surrounding rocks, the heat front lags behind of the heat displacement front (of the thermal fluid), and besides the smaller the thickness of the layer, the greater the lag, ceteris paribus. This is because on the low thickness of the layer the percentage of heat loss to upper and lower contacts of formation is more and the cooling of the thermal fluid is faster.

However, such a lag of the heat front also depends on the thermo physical and reservoir properties of the layer and thermal fluid, as well as on the efficiency of oil

displacement by water, where in the thickness of the reservoir at 10 meters after a year the thermal front will fall behind the displacement front for 13.3 times, and with the thickness of the layer 30m 9.1 times. Due to the latent heat of vaporization during steam condensation a warmed formation zone increases by 3-5 times (depending on the dryness of the injected steam and pressure). It is known that increase of the temperature leads to a decrease in viscosity and, hence, to the mobility of oil. With increase of the temperature decreases the surface tension of the oil reservoir on the border with brine water: at T - 20°C the surface tension of 6.05erg/cm^2, at 60°C - 2.34erg/cm^2.

The most promising direction of development of such layers is the use of thermal methods. The development of more efficient and improve existing methods of influence on these layers, with the use of economically and technologically advantageous thermal methods is urgent scientific and technical research direction. Accordingly, the subject of research, the results of which are presented in this article is to analyze the dynamics of oil production, the results of injecting steam at one of the development object of Karazhanbas oilfield.

3. RESEARCH RESULTS

Before starting the analysis of the injection of steam into the formation we analyzed the dynamics of indicators of oil production on one of the development object of Karazhanbas oilfield. At the beginning, the first development object of Eastern section of the deposit was exploited in a natural mode, then steam injection commenced in May 2010, uploaded 2,222,579 tons of steam, as a result of which, produced 664,221 tons of oil, where the current cumulative steam oil ratio for 2014 is 0.179 (Table 1). This shows the least positive effect of the development object on the eastern portion of the deposit (Analysis of the effectiveness …).

Table 1. Dynamics of production of oil and injection of steam at the eastern section of the deposit for 1 object

Date(years)	Annual production of liquid, thous.tons	Annual production of oil, thous.tons	Annual steam injection, thous.tons	Watercut,%	Accumulated production of oil from steam, thous.tons	Accumulated steam injection, thous.tons	Cumulative steam oil ratio(CSR)
2004	66,528	63,006		5			
2005	225,871	220,640		2			
2006	198,042	190,185		4			
2007	52,628	47,514		10			
2008	18,799	16,376		13			
2009	28,219	22,543		20			
2010	49,756	36,594	55,641	26	28,851	55,642	0,518
2011	167,776	101,404	153,000	40	130,255	208,642	0,663
2012	463,233	190,600	506,177	59	320,855	714,819	0,377
2013	646,476	193,050	667,069	70	513,905	1381,888	0,289
2014 for 9 months	616,951	150,316	840,691	76	664,221	2222,579	0,179

Fig. 1 Line Graph of the cumulative steam oil ratio from the accumulated oil on the Eastern section.

The effective thickness of the first development object characterized by highly permeable zones, thin layers. As can be seen from Figure 1, the current cumulative steam oil ratio is steadily declining year by year, should also pay attention to the trend of falling average daily oil flow rate per well, in spite of the growing fund of production and injection wells.

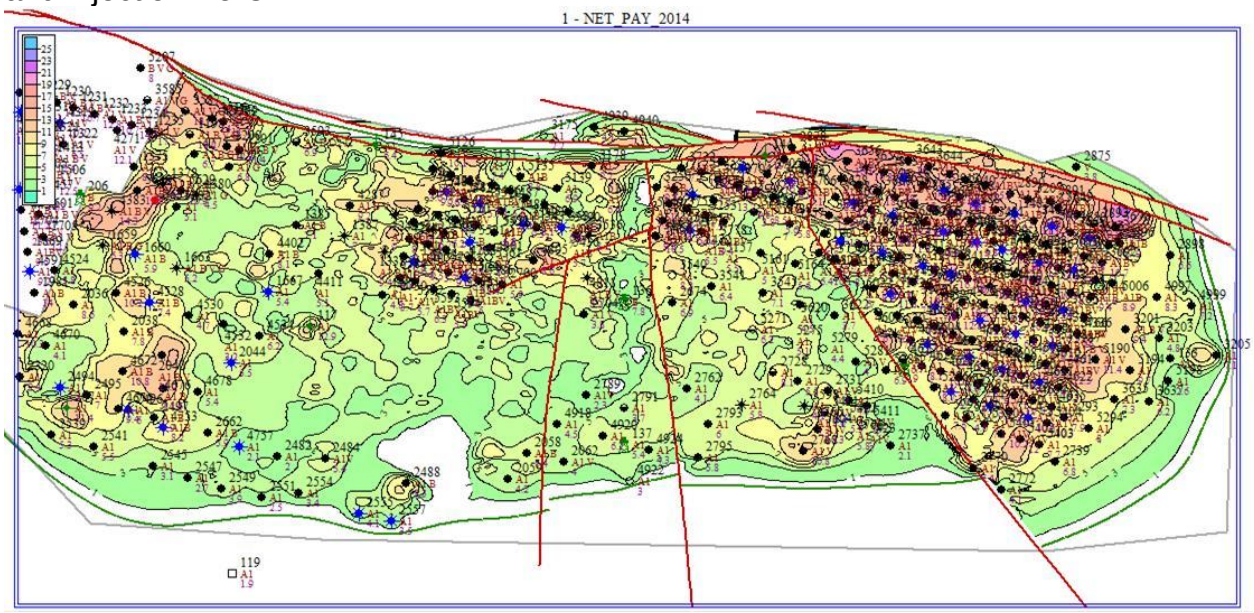

Fig. 2 Map of the effective thickness of the first object (horizons A1, B and C) on the eastern section of the deposit

On the map of effective thickness is represented the spread of the first object (the horizons A1, B and C) on eastern section of the field, where the average value of the effective thickness is 7.46 meters (Analysis of the effectiveness …).

Multiple constraints in steam injection in the last 3-4 years, where the injection of each well rose and fell from time to time, adversely affect the productive bottom hole formation zone, where there is pressure draw-down, drainage of zone, which leads to

clogging of bottom hole formation zone, as well as, taking into account the presence of clay interlayers, to the swelling clay and blockage of oil-bearing rock.

By taking into account the comparative charts and analysis of oil and injection wells in all zones of influence, for the development prospects of the field development, it is necessary to see the actual cumulative steam oil ratio across the deposit, which affects the further production of oil.

Achieving maximum productivity of wells requires continuous monitoring of well fund state in order to select the most promising wells for optimization of their production level. Successful management of oil production depends on the reliability of the procedure of potential assessment and the use of compensation method. The use of this approach in the development of deposit requires regular conduct such assessments for several thousands of wells in the field, operating in a variety of geological and technical conditions. Thus, the total wells operated by JSC "Karazhanbasmunai" is today more than 2.5 thousand. The account of features of operation of individual wells in these calculations is not possible (especially geological condition), because of the great uncertainty of input data (the calculation of formation pressure at individual wells) and inadequate formalization.

Assessing the potential of oil production wells at Karazhanbas oilfield is based on the calculation of the grade of down hole and formation pressures, so almost all the calculations carried out for the monitoring and optimization of wells, are the hydrodynamic calculation of multiphase flow parameters in their borehole. But, at the same time it is not possible to fully take into account the dependence of the producing wells from the steam injection wells in nine-spot pattern. Hereto, conducting hydrodynamic studies (in particular the reservoir pressure) on producing wells leads to downtime and further loss of daily oil production.

To solve the above problems, can be used the calculation of the potential oil production of individual wells using Dupuis formula by considering the theory of thermal effects on the oil reservoir by pumping the thermal liquid, and it in turn is based on the theory of multiphase multicomponent filtration with phase transitions, which requires knowledge of a wide range of information about oil-saturated reservoir. Fluid flow into the well with the zonal change in temperature is similar to the expression for Dupuis formula with zonal heterogeneity, since the formation temperature determines the viscosity of the filtered liquid:

$$Q = \pi k h r_w \Delta p \left(\frac{1}{\mu_T \ln(\frac{r_*}{r_w}) + \mu \ln(\frac{r_c}{r_*})} \right)$$

$P_{res.} \sim P_{bott.\ of\ inj.\ well}$

$r_c = \frac{\sigma}{2\pi}$

(1)

where μ - viscosity of reservoir fluid, μT - viscosity of oil that heated to a temperature Ts, k- absolute permeability, r_c - supply contour radius of well, Δp - depression in the reservoir, rw - well radius, r * - radius of the high-temperature zone

Assuming that the temperature distribution in the bottom zone is a piecewise constant function, velocity of the steam front is constant, and thermal losses are follow the law of Newton-Richman and can calculate the energy of combined heat losses of the heated area (Shevelev, 2005).

The method of compensation on the oilfield is used to calculate the compensability of steam injection with the actual liquid production, but nowadays the method of compensation with considering the potential production of fluid on the oilfield does not exist, that determines the relevance of this work.

Figure 3 shows examples of the four steam injection wells (further - siw) with eight reacting production wells in each on the first development object of the Eastern section of Karazhanbas oilfield. Table 2 shows the calculation of compensation for these four cells. As can be seen on the cell siw №3198 with injection volume of 102 tonn per day at the current operational factors of the flow rate of fluid production wells the compensability of the actual injection is 89.9%, which indicates the correct development of the cell. On the other hand, in siw №3765 everything is oppositely, the percentage of compensability is only 24%. It says that in this cell the fluid withdrawal from production wells is overstated, or the volume of steam injection is too low to compensate for the volume of production. In such cases, with the lack of complete information about wells any actions for optimization of cells of development can lead to irreversible consequences. Additional calculations on previously derived formulas for potential production to the compensation method can determine the right amount of steam for injection or highlight the wells, where need to optimize the exploitation rate for the proper distribution of injection in cells.

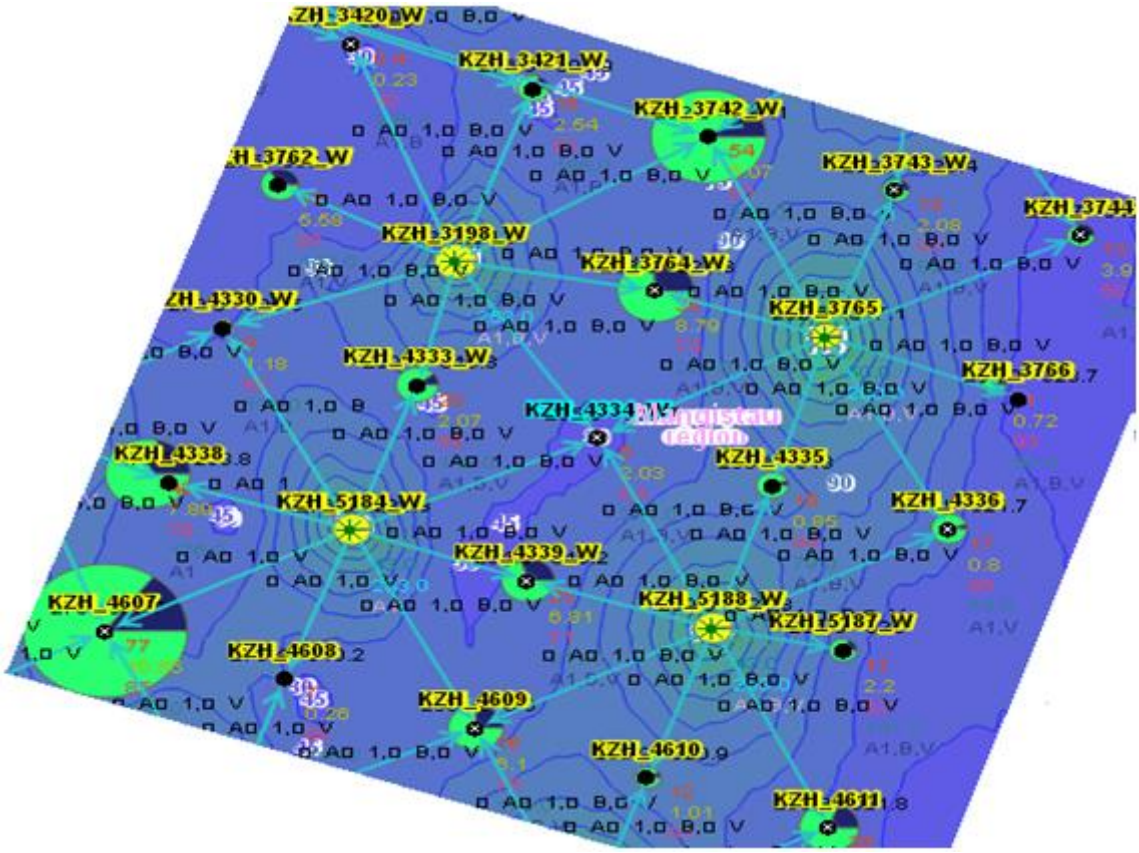

Fig. 3 Examples of the four steam injection wells with eight reacting production wells in each of the first object of the Eastern section

4. CONCLUSIONS

The application of the thermal method with steam injection at the Karazhanbas oilfield has its positive aspects, which are aimed at increasing the recovery of reservoirs, and as a result of the lack of more profitable technical and technological methods in the world practice, they remain the only ones for the field as in other countries at this time. From the technical side and from the side of petrophysical, geological conditions of the reservoir as well as the characteristics of the oil, the application of the thermal method have good performance. But taking into account the cumulative steam oil ratio reduction and uneven development of cells for at the first object, one can confirm the theory of fast steam consumption in the reservoir and the absence of heat conservation. Also, work to regulate production and injection wells in the injection areas of steam in the field is not effective enough.

To summarize, for right correction and regular monitoring of the regimes of producing and injecting wells and their correct optimization at the Karazhnbas oilfield, on the basis of the above calculations and method, it is recommended to display a clear picture of the hydrodynamic processes and measures for regulation of the distribution and effect of steam on the cells of the steam injection wells. For example:

If the potential flow rate of liquid is higher than the actual one, and also the percentage of injection compensation is more than 100, it is possible to propose optimization of wells that are suitable for these criteria and gain an increase in the flow rate of liquid and oil.

Table 2. Calculations of compensation of fluid withdrawal for the four cells

№	Object of exploitation	№ injection well	№ of producing well in the cell	Number of influencing injection well	Group unit	Technical regime for the 1st quarter of 2016					The fact for February 2016, average daily, tons / day						The fact for February 2016, average daily			actual compensation factor, %
						injection		producing			injection			producing			injection	producing		
						Q injection	Pbuffering	Qliq	%	Qoil	Q injection	Q injection	Pbuffering	Qliq	%	Qoil	Qinj/N1	Qliq/N2	Qoil	
1	**3**	**4**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
1	I	**3198**	**3420**	**1**	31 п	150	20	1	40	0,6	102	17	21	1	49	0	13	1	0	89,9
			3421	**1**	31 п			13	75	3,1				15	82	3		15	3	
			3742	**2**	31 п			51	83	8,1				65	86	9		33	5	
			3762	**1**	31 п			11	77	2,4				21	75	5		21	5	
			3764	**2**	31 п			13	70	3,7				20	79	4		10	2	
			4330	**2**	31 п			20	98	0,4				28	97	1		14	0	
			4333	**2**	31 п			24	80	4,5				34	81	6		17	3	
			4334	**4**	31 п			6	54	2,6				7	51	3		2	1	
2	I	**3765**	**3742**	**2**	31 п	27	30	51	83	8,1	27	30	35	65	86	9	3	33	5	24,1
			3743	**1**	31 п			15	87	1,8				16	88	2		16	2	
			3744	**1**	31 п			13	72	3,4				15	80	3		15	3	
			3764	**2**	31 п			13	70	3,7				20	79	4		10	2	
			3766	**1**	31 п			10	90	0,9				14	86	2		14	2	
			4334	**4**	31 п			6	54	2,6				7	51	3		2	1	
			4335	**2**	31 п			13	95	0,6				18	96	1		9	0	
			4336	**2**	31 п			17	93	1,1				25	96	1		12	0	
3	I	**5184**	**4330**	**2**	31 п	63	22	20	98	0,4	63	22	28	28	97	1	8	14	0	28,5
			4333	**2**	31 п			24	80	4,5				34	81	6		17	3	
			4334	**4**	31 п			6	54	2,6				7	51	3		2	1	
			4338	**1**	31 п			41	82	6,9				53	81	10		53	10	
			4339	**2**	31 п			16	72	4,2				30	71	8		15	4	
			4607	**1**	31 п			62	88	7				93	88	11		93	11	
			4608	**1**	31 п			4	92	0,3				8	96	0		8	0	
			4609	**2**	31 п			21	72	5,5				34	81	7		17	3	
4	I	**5188**	**4334**	**4**	31 п	61	26	6	54	2,6	61	26	30	7	51	3	8	2	1	50,3
			4335	**2**	31 п			13	95	0,6				18	96	1		9	0	
			4336	**2**	31 п			17	93	1,1				25	96	1		12	0	
			4339	**2**	31 п			16	72	4,2				30	71	8		15	4	
			4609	**2**	31 п			21	72	5,5				34	81	7		17	3	
			4610	**1**	31 п			12	87	1,5				14	88	2		14	2	
			4611	**1**	31 п			28	83	4,5				36	90	4		36	4	
			5187	**1**	31 п			13	85	1,8				15	86	2		15	2	
		Итого:												**835**	**83**	**132**				
N1 - the quantity reacting to well production in the cell, N2 - the number of influencing injection wells, to this production well												**β=1,012**	**ρ=0,9292**							

Table 3. Calculations of compensation of fluid withdrawal for the four cells with considering the potential production of fluid

						Technical regime for the 1st quarter of 2016					The fact for February 2016, average daily, tons / day						The fact for February 2016, average daily																		
						injection		producing			injection			producing			injection	producing																	
№	Object of exploitation	№ Injection well	№ of producing well in the cell	Number of influencing injection wells	Group unit	Q injection	Pbuffering	Qliq	%	Qoil	Q injection	Pbuffering	Pbottom	Qliq	%	Qoil	Q inj/N1	Qliq /N2	Qoil	actual compensation factor, %	potential Qliq	potential Qoil	watercut	increase in oil	H perforating,м	P bottom	skin factor	viscosity of oil in reservoir conditions	viscosity of water in reservoir conditions	viscosity of liquid	volume factor (β)	density of water (ρ)	K permeability	distance to the injection well	diameter production casing
1	3	4	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
1	I	3198	3420	1	31 п	150	20	1	40	0,6	102	17	21	1	49	0	13	1	0	89,9	1	0,4	40	0	8,2	2,1	0	541	1,63	14,8	1,0	1,02	0,0	220	168
			3421	1	31 п			13	75	3,1				15	82	3		15	3		26	6,2	75	3,3	11,7	7,1	0	541	1,63	6,72	1,0	1,02	0,8	150	168
			3742	2	31 п			51	83	8,1				65	86	9		33	5		106	16,9	83	7,8	10,4	6,6	0	541	1,63	6,49	1,0	1,02	3,6	147	168
			3762	1	31 п			11	77	2,4				21	75	5		21	5		19	4,2	77	-1	9,4	9,7	0	541	1,63	7,73	1,0	1,02	1,1	157	168
			3764	2	31 п			13	70	3,7				20	79	4		10	2		56	15,7	70	11,4	15,4	10,1	0	541	1,63	7,24	1,0	1,02	1,8	141	168
			4330	2	31 п			20	98	0,4				28	97	1		14	0		19	0,4	98	-0,5	8,8	13,8	0	541	1,63	5,64	1,0	1,02	1,3	193	168
			4333	2	31 п			24	80	4,5				34	81	6		17	3		47	8,8	80	2,4	10,4	11,4	0	541	1,63	7,01	1,0	1,02	2,5	122	168
			4334	4	31 п			6	54	2,6				7	51	3		2	1		22	9,4	54	6,1	8,3	3,1	0	541	1,63	11,8	1,0	1,02	1,4	204	168
2	I	3765	3742	2	31 п	27	30	51	83	8,1	27	30	35	65	86	9	3	33	5	24,1	209	33,4	83	24,3	10,4	6,6	0	541	1,63	6,49	1,0	1,02	3,6	147	168
			3743	1	31 п			15	87	1,8				16	88	2		16	2		33	4,1	87	2,1	9	17,2	0	541	1,63	6,31	1,0	1,02	1,1	208	168
			3744	1	31 п			13	72	3,4				15	80	3		15	3		31	8	72	5	7,3	9,4	0	541	1,63	7,07	1,0	1,02	0,9	150	168
			3764	2	31 п			13	70	3,7				20	79	4		10	2		127	35,8	70	31,6	15,4	10,1	0	541	1,63	7,24	1,0	1,02	1,8	141	168
			3766	1	31 п			10	90	0,9				14	86	2		14	2		39	3,7	90	1,9	7	13,0	0	541	1,63	6,48	1,0	1,02	1,3	164	168
			4334	4	31 п			6	54	2,6				7	51	3		2	1		39	16,8	54	13,5	8,3	3,1	0	541	1,63	11,8	1,0	1,02	1,4	204	168
			4335	2	31 п			13	95	0,6				18	96	1		9	0		26	1,2	95	0,6	6,7	20,2	0	541	1,63	5,7	1,0	1,02	1,1	146	168
			4336	2	31 п			17	93	1,1				25	96	1		12	0		48	3,1	93	2,2	8,2	20,7	0	541	1,63	5,68	1,0	1,02	1,9	209	168
3	I	5184	4330	2	31 п	63	22	20	98	0,4	63	22	28	28	97	1	8	14	0	28,5	37	0,7	98	-0,1	8,8	13,8	0	541	1,63	5,64	1,0	1,02	1,3	193	168
			4333	2	31 п			24	80	4,5				34	81	6		17	3		81	15,2	80	8,9	10,4	11,4	0	541	1,63	7,01	1,0	1,02	2,5	122	168
			4334	4	31 п			6	54	2,6				7	51	3		2	1		30	13,1	54	9,8	8,3	3,1	0	541	1,63	11,8	1,0	1,02	1,4	204	168
			4338	1	31 п			41	82	6,9				53	81	10		53	10		50	8,4	82	-1,6	6,9	11,5	0	541	1,63	6,89	1,0	1,02	2,3	143	168
			4339	2	31 п			16	72	4,2				30	71	8		15	4		56	14,7	72	6,2	9,2	8,8	0	541	1,63	8,11	1,0	1,02	2,0	146	168
			4607	1	31 п			62	88	7				93	88	11		93	11		198	22,3	88	10,9	9	10,5	0	541	1,63	6,4	1,0	1,02	6,6	183	168
			4608	1	31 п			4	92	0,3				8	96	0		8	0		2	0,1	92	-0,2	9,1	7,8	0	541	1,63	541	1,0	1,02	3,5	147	168
			4609	2	31 п			21	72	5,5				34	81	7		17	3		59	15,6	72	9	7,6	15,3	0	541	1,63	6,81	1,0	1,02	3,5	211	168
4	I	5188	4334	4	31 п	61	26	6	54	2,6	61	26	30	7	51	3	8	2	1	50,3	33	14,2	54	10,9	8,3	3,1	0	541	1,63	11,8	1,0	1,02	1,4	204	168
			4335	2	31 п			13	95	0,6				18	96	1		9	0		17	0,8	95	0,2	6,7	20,2	0	541	1,63	5,7	1,0	1,02	1,1	146	168
			4336	2	31 п			17	93	1,1				25	96	1		12	0		31	2	93	1,2	8,2	20,7	0	541	1,63	5,68	1,0	1,02	1,9	209	168
			4339	2	31 п			16	72	4,2				30	71	8		15	4		62	16,2	72	7,7	9,2	8,8	0	541	1,63	8,11	1,0	1,02	2,0	146	168
			4609	2	31 п			21	72	5,5				34	81	7		17	3		69	18	72	11,5	7,6	15,3	0	541	1,63	6,81	1,0	1,02	3,5	211	168
			4610	1	31 п			12	87	1,5				14	88	2		14	2		36	4,4	87	2,7	12,2	18,4	0	541	1,63	6,29	1,0	1,02	1,2	149	168
			4611	1	31 п			28	83	4,5				36	90	4		36	4		120	19,2	83	15,5	13	17,1	0	541	1,63	6,21	1,0	1,02	3,7	214	168
			5187	1	31 п			13	85	1,8				15	86	2		15	2		28	4	85	1,9	7,9	17,3	0	541	1,63	6,46	1,0	1,02	1,3	105	168
		Итого												835	83	132					1757	337,2	79,6	205,2											
N1 - the quantity reacting to well production in the cell, N2 - the number of influencing injection wells, to this production well																									β=1,012		ρ=0,9292								

If the potential flow rate is lower than the actual one, and also the percentage of compensation by injection below 80-90, it is possible to suggest an increase in steam consumption while increasing the bottomhole pressure of the injection well. In this case, attention should be paid to the wells in which the thermal front is already in the bottomhole formation zone. There are recommended to reduce depression to direct the heat front to the other side of the cell for a uniform distribution.

The calculations and methods developed in this article are only an initial step in the optimization and monitoring of the development of production wells in the areas of the steam injectionof the Karazhanbas oilfield.

REFERENCES

Turkov V.O. (2014). “The geological and technical information for the Karazhanbas oilfield”. http://www.springer.com/us/book/9783319090719

“Analysis of the effectiveness of the impact of steam injection on the eastern section and impact of the hot water of the Western Karazhanbas”.

Shevelev A.P. (2005). “Mathematical modeling of thermal impacts on oil reservoirs”, Tyumen.

“Steam injection impact to the formation”. proofoil.ru/Oilproduction/Steamaction.html

“Heavy oil production” (2010). www.to-inform.ru/index.php/arkhiv/item/добыча-тяжёлой-высоковязкой-нефти

Ghoodjani E, Kharrat R, Vossoughi M, Bolouri SH (2011). “A Review on Thermal Enhanced Heavy Oil Recovery from Fractured Carbonate Reservoirs”. *J Phylogenetics Evol Biol,* Vol. **2**(109), doi:10.4172/2157-7463.1000109

Zhao X., Gao P. and Wu Y. (2013). “Superheated steam injection in North Kenkiyak shallow heavy oil reservoir”. *Journal of Geology and Mining Research*, Vol.**5**(6), 136-146

Esetov Zh. A., Turdiyev M. F., Kemalov A. F. and Abdrafikova I. M. (2016). “Thermal-Steam Cyclic Processing Technology of Development Objects In Karazhanbas Kazakhstan Field”. *Indian Journals of Science and Technology*, Vol **9**(18), DOI: 10.17485/ijst/2016/v9i18/93749, 1-7

Barillas J. L. M., Dutra T. V. Jr., Mata W. (2008). “Improved Oil Recovery Process for Heavy Oil: A Review”. *Brazilian Journal of Petroleum and Gas*, Vol. 2, 45-54

Briggs, P.J., Fulleylove, R.J., Wright, M.S., Baron, R.P. (1987). Development of heavy oil reservoirs. *In: Fifth SPE Middle East Oil Show*, Manama, Bahrain, March 7-10, technical paper SPE 15748.

Thomas, J.E., Triggia A.A., Correia C.A. et al. (2001). “Fundamentos de Engenharia de Petroleo”. *Editora Interciencia,* Rio de Janeiro, Vol. 7,169-174 (in Portuguese)

Nasr, T. N. Ayodele, O. R. (2005). “Thermal techniques for the recovery of heavy oil Bitumen”. *In: SPE International Improved OIL conference in asia pacific held in Kuala Lumpur*, Kuala Lumpur, Malaysia, 5-6 December, technical paper SPE 97488.

Butler R.M. (1991). “Thermal Recovery of oil and bitumen. Department of Chemical and Petroleum Engineering”. *Prentice Hall,* New Jersey, Vol. 7, 285-358