ANALYSIS OF SHORT-TERM WELL OPERATION AND RECOMMENDATIONS FOR ELECTRIC SUBMERSIBLE PUMP OPTIMIZATION

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Using of continuous well operation of Electric Submersible Pump (ESP) for low productivity well stock has one significant disadvantage, such as inability to change the pump performance effectively without a well remedial work. A throttling is used for this purpose. However, it reduces the effectiveness of ESP, while increasing power consumption. Automatic periodic well operation (high values of pumping and accumulation times) has several disadvantages such as loss of oil production rate, increased energy consumption and difficulties in well operation during winter. Based on result of industrial tests, the reduction of power consumption and increasing of the production rate were achieved by using of periodic short-term well operation.

In fact, the entire low productivity well stock is allocated between ESP and rod pump artificial methods while alternative production methods are insignificant in the considered wells. Giving preference to a particular method of well operation, oil and gas companies are trying to provide the highest possible level of oil production at minimum total unit costs. This is achieved by reducing capital and operating costs.

Periodic short-term well operation (ESP) is the pumping from a well alternating with accumulation of incoming fluid from a reservoir. In another words, the pump is only operating when there is certain level of fluid accumulated in a well. During fluid accumulation the pump is in the standby mode. The pump, which is used for production, has 3 to 5 times higher delivery rate than reservoir inflow.

This mode of well operation increases the efficiency of low productivity wells. This is due to the fact that more powerful performance pumps have higher efficiency compared to low productivity pumps. Periodic short-term well operation allows increasing the mean time before failure of the wells. In this mode pump operates only part-time and for the rest of the time is inactive, thus it does not wear out as much. It can be concluded that periodic short-term well operation also helps to reduce the influence of mechanical impurities and scaling deposition, since larger pumps have larger flow section diameter [2].

The purpose of this paper is to analyze the technological effect of the proposed mode of periodic short-term well operation as well as development of recommendations for selection and cyclical operation mode of submersible equipment based on the example of oilfield A.

Methods of research included mathematical calculations of pumping and accumulation times. The cycle time (sum of pumping and accumulation times) is directly affected by liquid production. Dynamic head decreases when liquid is accumulated in the well. Correspondingly, the bottomhole pressure increases, while drawdown and reservoir inflow decrease. Therefore, it is necessary to approximate the average bottomhole pressure to the target bottomhole pressure. Average bottomhole pressure is the average value between the upper and lower boundaries of pressure at the start and stop of ESP. The target bottomhole pressure is the minimum pressure that is achieved at the end of the cycle of liquid pumping from the well [3]. Two methods used for calculation of cycle time: calculation based on well production data and calculation based on downhole pressure gauge.

The results of calculation are shown on the example of one of the wells, which is exploited in periodic short-term well operation. Calculation based on downhole pressure gauge is more preferred because this data is the basis for cycle time well operation determination. Consider one of low productivity wells, which has downhole pressure gauge data. Measurement of dynamic level build-up curve is presented in Table 1.

Table 1

Dynamic level build-up data

Time, hour:min:sec	Downhole pressure gauge, atm	Dynamic level, m	Change in level, m	Reservoir inflow, m^3/hour	Liqiud rate, m^3/day
03:58:53	35	2482			
04:58:52	39	2426	56	0.77	18.6
05:58:51	42	2382	44	0.60	14.4
06:58:50	45	2341	41	0.56	13.5
07:58:48	48	2298	43	0.59	14.2
08:58:47	51	2256	42	0.57	13.7
09:58:46	53	2228	28	0.39	9.3
10:58:45	56	2186	42	0.58	13.9
11:58:44	58	2158	28	0.39	9.3
12:58:43	60	2129	29	0.39	9.5
13:58:42	62	2101	28	0.38	9.1
14:58:41	64	2074	27	0.38	9.0

This data helps to find the dependency of the reservoir influx relative to dynamic level, which in turn directly influences bottomhole pressure. The reservoir inflow is calculated as follows [1]:

With increase of fluid level in the well, the reservoir inflow should decrease due to increased bottomhole pressure. However, contradictory information is obtained according to the calculations presented in Table 1. As the fluid level increases, the reservoir inflow starts to fluctuate. The reason for such fluctuations is limited downhole sensors instrument resolution. To resolve the problem, it is recommended to interpolate the values of dynamic levels by smooth curve using the trend line, such as a third-order polynomial equation. After that new values of reservoir inflow are derived using the interpolated curve.

The problem of determination of the cycle time is to find the maximum liquid level in the well when the pump starts to work. It is necessary to consider the maximum allowable percent deviation from the target production rate, minimum flow rate required for cooling the motor and the maximum allowable number of pump starts per specific time period. It is also necessary to take into account the reservoir inflow during pump operation.

Accumulation time from the target level to maximum level is determined by using the dynamic level build-up curve.

Table 2 shows that the variations in cycle time change the current dynamic level, respectively, average bottomhole pressure and flow rate change.

Table 2

Dynamic level build-up data

Cycles in day	Dynamic level, m	Pumping time in one cycle, hour:min:sec	Accumulation time in one cycle, hour:min:sec	Liqiud rate, m3/day
	2480			
87	**2470**	**0:5:38**	**0:11:00**	**18.61**
44	2459	0:11:08	0:22:00	18.49
22	**2439**	**0:21:50**	**0:43:59**	**18.24**
15	2420	0:32:06	1:05:59	18
8	2373	0:56:03	2:00:58	17.42
4	2274	1:44:59	4:12:55	16.13
3	2216	2:12:09	5:40:54	15.36
2	2106	3:01:42	8:58:50	13.87

When the number of cycles per day is increased from 22 to 87, the liquid flow rate is increased by 0.37 m^3/day. The difference in oil production rate for considered well is 0.3478 m^3/day, and the difference in monthly oil production rate is 10.434 m^3/month when water cut is 6%. The increased number of ESP start-ups can cause a reduction in the mean time before failure. Therefore, it is necessary to take into account economic and technological parameters.

Field A wells, operated in periodic short-term well operation mode are utilized on hourly bases cycles. According to the calculations conducted during the study, it can be concluded that reduction in cycle period leads to increased fluid flow rate by 2-4% at the expense of reduced target bottomhole pressure. In such case, the probability of equipment breakdown is increased due to higher frequency of start-ups and shut-downs. Therefore, operation in such mode can produce higher equipment loads, which can be minimized by using variable frequency drive technique.

References

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