

# Scenario approach for increasing efficiency of wells operation with the horizontal termination

R A Kozikhin <sup>1</sup>, I G Fattakhov <sup>1,2,3</sup>, L S Kuleshova <sup>2</sup>, A Kh Gabbasov <sup>1</sup>

<sup>1</sup>PJSC TATNEFT named after V.D. Shashin, 75, Lenin St., Almetyevsk, Republic of Tatarstan, 423450, Russian Federation

<sup>2</sup>Ufa State Petroleum Technological University, Branch of the University in the City of Oktyabrsky, 54a, Devonskaya St., Oktyabrsky, Republic of Bashkortostan, 452607, Russian Federation

<sup>3</sup>SBEI of HE “Almetyevsk State Oil Institute”, 2, Lenin St., Almetyevsk, Republic of Tatarstan, 423450, Russian Federation

E-mail: [vsh@of.ugntu.ru](mailto:vsh@of.ugntu.ru); [i-fattakhov@rambler.ru](mailto:i-fattakhov@rambler.ru)

**Abstract.** The aim of this work is to reveal causes of unprofitable horizontal tailing-in well operation, their further ranking according to the degree of influence, and developing reactive and pro-active measures on increasing efficiency of wells in operations as well as planned wells. During this work the retrospective analysis of horizontal termination well operation stock (horizontal well, horizontal sidetrack, horizontal drainhole well), and the analysis of current state were carried out. The influence of the conducted wellbore interventions on economic efficiency of well operations was estimated. According to the results, obtained in the research, the main direction of works on increasing efficiency will be scenario approach to planning investments at the wells. It must be considered future (potential) wellbore interventions at the wells as an integral part of well operation. It is necessary to calculate total investment attractiveness of projects on oil extraction, including the following elements: well construction; operation; in-flow stimulation; water suppression; effects via injection well stock; abandoning. Such approach to planning investments will allow to carry out correct comparative assessment of the existing well operations and repairs technologies with new ones which can push up the cost of separate subprojects, but at the same time enhance its investment attractiveness.

## 1. Introduction

PJSC Tatneft has developed oil fields by the wells with horizontal tailing-in for more than 20 years. Against the gain from drilling volume of the proportion horizontal tailing-in wells there is a problem of unprofitable horizontal wells growing number.

Developing new technologies in the field of operating, surveying and repairing wells with the horizontal tailing-in gives a number of instruments to restore their profitability. Herewith, according to the special conditions of developing main fields of PJSC Tatneft – the high reserves depletion and water cut, increasing number of hard-to-recover oil reserves and limited potential of wells – there are barriers for one or another technology from the perspective of economic justifiability of their usage.



The state analysis of an unprofitable stock of wells with horizontal tailing-in has been carried out to determine limits to applicability of new technologies and to define an algorithm of selecting the method of well profitability restoration depending on its potential.

The unprofitable well is the well with the profitability  $R_{it}$  less than 15% [1]:

$$R_{it} = \frac{(P - H_p) \cdot Q_{n_{it}} - 3_{it}}{3_{it}} \cdot 100\%,$$

where:  $R_{it}$  is profitability, %,

$P$  is weighted average sale price of a tone of oil in respect all market outlets incl. of VAT and export duty, rub/t,

$H_p$  is taxes, paid to the budget from oil sale price (VAT and export duty), rub/t,

$Q_{n_{it}}$  is oil output on i-well for baseline period (t), t,

$3_{it}$  – oil extraction and sales costs on i-well for baseline period (t), rub.

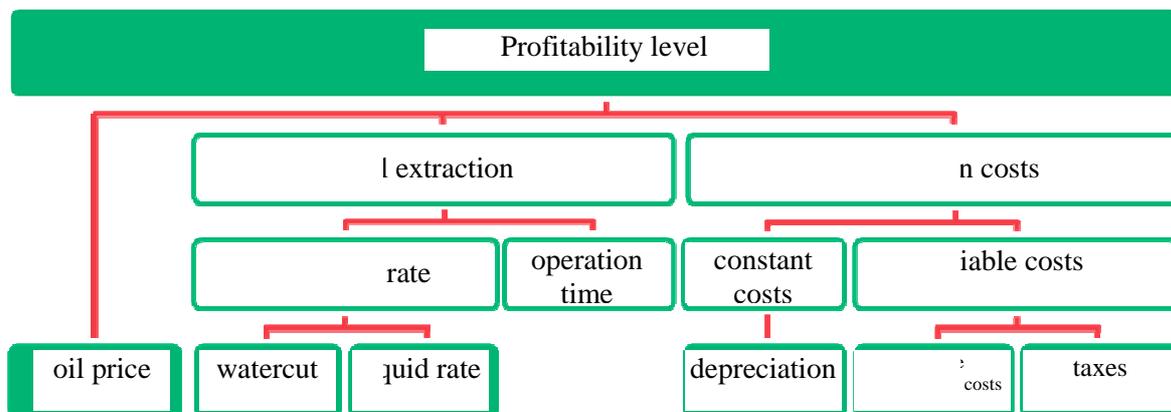
## 2. Methods and materials

The obtained results, described in the article, are based on the analysis of well operations, history of carried out geological and technical actions, economic indicators. To process data we used methods of statistical analysis, factor analysis, sensitivity analysis by method of chain substitutions.

## 3. Results and discussion

The main factors influencing on well profitability are (figure 1): oil sale price; crude oil output depending on oil flow rate and operation time. Additionally, oil extraction costs, consisting of constant and variable costs [2-3], belong to the factors, influencing profitability.

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**Figure 1.** The main factors influencing well profitability

Constant costs on oil extraction are the most significant in respect of influencing on the level of wells profitability as they establish a peculiar "stock" of profitability and regulate well sensitivity to changes of other indicators (fall in oil prices, increase of water production, carrying out failing well interventions on a production well or actions on influencing injection wells) [4]. As the main component of constant costs of oil production are depreciation allowances, this statement is true for wells during depreciation period and is applicable to the average annual operating (AAO) fund which main part (81%) at the time of the analysis is not depreciated.

The size of depreciation allowances depends on the well construction cost and the duration of the depreciation period [5]. Recently there has been a growth of well construction costs. It should be noted that, growth rates of cost of conditionally horizontal well are higher than growth rates of costs of conditionally vertical well. Significant increase in costs of horizontal wells construction primarily is

connected with the introduction of new expensive technologies of drilling and re-equipment of drilling service.

Against the background of increasing well construction costs during the period under consideration the depreciation period has been reduced [6]:

- till 2002 – 15 years;
- since 2002 to 2009 – 11 years;
- since 2010 – 8 years.

Mutual increase in the cost of well construction and reducing of the depreciation period has led to the growth of level of constant costs during depreciation.

Based on dynamics archive of indicators work of horizontal tailing-in wells (oil production decline rates, growth of water cut), taking the price of 1 tonne of oil and a MET rate as constant at the level of 2013, we has created the average balance between costs of oil extraction and its sales revenue for wells with horizontal tailing-in. The period of depreciation was of 8 years [7, 8].

Results of the analysis demonstrate the decrease in profitability of the average well till 6-8 year of operation. It is connected with falling well extraction capabilities till this period. Decrease in well extraction capabilities is connected either with the decrease of well efficiency, or with the increase in percent of water cut oil production [9]. The wells operating experience of the horizontal tailing-in well shows that for 6-8 year after drilling the initial output of oil on average has decreased by 2,5-3 times. The water cut of production by this period in the prevailing part of wells increases to 80% [10]. It should be noted that the wells developing carbonate collectors are flooded in the first 2 years [11].

On the one hand, 6-8 years of operation are characterized by high sensitivity of well profitability to surrounding conditions, such as: oil price; increase in variable expenses, including well interventions directly on a production well and on the influencing delivery wells [12].

On the other hand, critical falling of the well efficiency or increase in water content of the got production at this period becomes a trigger to carry out well interventions on this fund [13].

Thus, the high level of constant expenses leads to considerable influence of variable costs of wells profitability on well profitability.

As it presented in the table 1, the main reasons for unprofitability of wells with horizontal tailing-in it is possible to name decreasing output of liquid rate, increase in water cut of production and carrying out technical actions directly on a production well or on the influencing delivery well [14].

**Table 1.** Wells dividing according to unprofitability (variable costs)

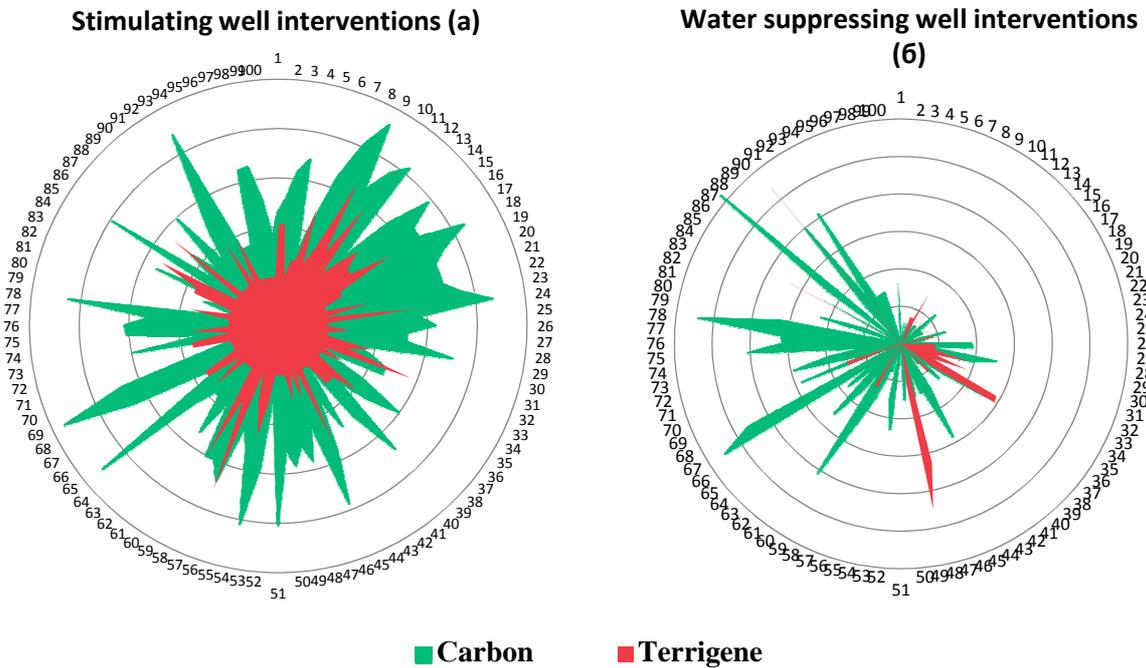
Unprofitability Causes	Категория	rate of wells									
		2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Low productivity	Низкая продуктивность	53%	53%	46%	53%	28%	41%	41%	47%	25%	39%
High watercut	Высокая водопроницаемость	34%	39%	29%	35%	16%	30%	32%	32%	19%	38%
Well interventions costs	Расходы на работы	3%	4%	3%	3%	1%	0%	7%	11%	9%	14%
Fall in Oil price	Падение цены на нефть	10%	4%	22%	3%	55%	27%	20%	10%	45%	9%
		0%	0%	1%	7%	0%	2%	0%	0%	2%	0%

Increase in number of unprofitable wells in the years of oil prices reduction (2006, 2008 and 2012) as well as in the later years of prices restoration (2009, 2010 and 2011) demonstrates considerable influence of oil price on wells profitability. But, due to the lack of a leverage over this factor it is not considered in the further analysis.

The rate of wells with horizontal tailing-in, unprofitable for such natural reasons, as a low liquid rate or high water cut of production is almost permanent during the time.

The analysis reveals that the current number of profitable wells extremely seldom exceeds the number of profitable wells directly within the year of their drilling. This indirectly means that the wells, unprofitable after drilling, cannot practically be transferred to a profitable fund [15].

One of the reasons of transferring profitable (commercial) wells to an unprofitable fund is carrying out wellbore interventions at wells with horizontal tailing-in (figure 2).



**Figure 2.** Distributing specific quantity of well interventions (WI) from AAO at Carbon deposits, WI/well. during 100 months after drilling

As it was mentioned earlier, the influence of variable costs on profitability of wells is possible if we meet two conditions: decreasing of well extraction opportunities (the average period of operation is 6-8 years) and depreciation allowances in the current period [16].

Existing (till 2013) and expected dynamics of the wells with horizontal tailing-in (till 2020) meeting the condition: not depreciated wells with the 7 years term of operation have shown that the period of increase in influence of a factor of conducting well interventions coincides with the sharp increase in number of the wells having reached the seven-year term of operation but not having gone beyond the depreciation period.

Thus, 2013-2018 years can be named as the period, especially sensitive to success of conducting well interventions, and the period of a temporary increase in a rate of unprofitable wells. Next years there will be a natural reduction in number of wells which profitability depends on increase in variable costs, and, as a result, it is possible to expect reduction in a rate of an unprofitable well stock with the horizontal tailing-in.

To account such regularities of dynamics in well profitability it is necessary to transfer to the scenario approach in planning investments on a well. Need to consider well interventions as an integral part of operation of the well has increased, as well as to count total investment attractiveness of the oil production project including the following subprojects: well construction and operation; inflow stimulation; water suppression; influence through injection well stock; abandoning.

The given approach to planning investments will allow to carry out correct comparative assessment of existing technologies of operation and repair RGP (Radioactive Gas Processing) with new technologies, which can increase the cost of separate subprojects, but, at the same time, increasing its investment attractiveness.

#### 4. Conclusion

1. The main reason of unprofitability of wells with horizontal tailing-in for the last three years on an equal basis with a low well flow index and high water cutting of well production is the conducting of well interventions (increase in variable costs).
2. Influence of variable costs on wells profitability has become possible because of increase in constant costs.
3. Reduction of depreciation period and increase in cost of wells construction have led to the growth of level of constant costs during depreciation period.
4. The analysis has shown that the decrease in profitability of an average well with horizontal tailing-in happens after 6-8 years of operation. It is connected with decline of well extraction opportunities by this period.

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