

Economic tools for realization of methane production project on Kuzbass coal deposits

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Abstract. Environmental issues and, above all, issues related to the release of greenhouse gases into the atmosphere, such as coal bed methane, actualize the challenge of searching a variety of options for its disposal. The difference in the macroeconomic, industrial, geological and infrastructural features determine the need to choose the most cost-effective option for using of methane emitted from the coal deposits. Various economic ways to improve the profitability of production are viewed on the basis of the analysis of methane production project from Kuzbass coal deposits, Kemerovo region, Russia.

1. Introduction

Coal mine or coalbed methane is methane, which is released into the surrounding rocks. It is explosive at concentrations of 5-15%. This fact may lead to economic, environmental and social consequences. Furthermore, the release of methane into the atmosphere contributes to the greenhouse effect [1]. Its impact is many times greater than the impact of carbon dioxide. According to the US Environmental Protection Agency, in the global human impact on the atmosphere, the share of coal-bed methane is 8-10% [2, p.1]. For example, in the USA in 2014 the share of coalbed methane was 9% [3]. The impact of human activity on the quality of the atmosphere is the basic factor for alternative energy industry development [4].

One of the positive characteristics of methane is its energy value, which is used to reduce methane concentration in the coal beds and to eliminate negative impact of methane on the environment.

Production of methane from coal beds, as an independent mineral resource, has been carried out for more than 40 years in the world. The USA and Australia are the leaders in methane production. Currently methane is used:

- in electricity generation for gas engines and turbines;
- in pipelining;
- as a boiler fuel for heating;
- as a heat source for the coal mine air ventilation and coal drying.

Utilization of coalbed methane depends on the quality of gas (concentration of methane and the presence of impurities), and the economic efficiency of variety of ways of its use. Thus, during methane transportation the gas concentration should be at least 95%. Also such methane can be used as a motor fuel. For electricity generation the concentration should be of more than 25% [5]. Therefore, issues of cost-effectiveness of different options for methane use are of particular importance in the world [6, p.21].

2. Project realization aspects of methane production from coal deposits in Kuzbass

The project "Methane production from Kuzbass coal deposits" (Kemerovo region) implemented by "Gazprom Dobycha Kuznetsk" LLC is the first project of such kind in Russia. This project has a double purpose: production of an important raw material for gas provision to Kemerovo region and subsequently the creation of safe conditions of miners' work by advance degassing of coal deposits.



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The development and exploitation of CBM wells, due to the specific features, requires a forced pumping of associated formation water. Only after complete drainage of simultaneously developed groups of productive coal deposits maximum production rates of wells are achieved.

As a rule, at well completion, the productive reservoirs (up to 8 production facilities in one well) are subjected to additional stimulation by hydraulic fracturing. In this regard, the development of CBM wells has to be carried out in two stages.

The first, development stage, allows indirectly to determine the production potential of reservoir fluid and gas, to choose the most suitable size of pump equipment and minimize the risks of downhole equipment failure, due to the clogging of operating facilities by hydraulic fracturing products and coal slurry. The experience of well operation allowed setting the most optimal depth of downhole pumping equipment (DPE) running at the first stage of development - 50 m above the perforated interval of upper operating facility. At the second stage the assembly runs to the projected depth below the last perforated interval [7, p. 15].

At reducing the dynamic level of the reservoir fluid the moment of gas desorption should be controlled (increasing of pressure in the annulus) as well as the physical properties of the pumped formation fluid. If possible, the operation of DPE should be excluded.

3. Analysis of equipment operation during project realization.

Currently, 23 downhole units are operating in the wells of Taldynskoe and Naryksko-Ostashkinskoe deposits: sucker-rod screw pumps, electrical submersible pump units of different size and balanced pumping units.

Sucker-rod screw pumps were more optimal under the conditions of CBM deposits development.

The analysis of sucker-rod screw pump exploitation for the period from 2009 to 2015 (Figure 1) has shown that operating time in 2015 on well stock was 640 days, and the maximum operating time was 1150 days.

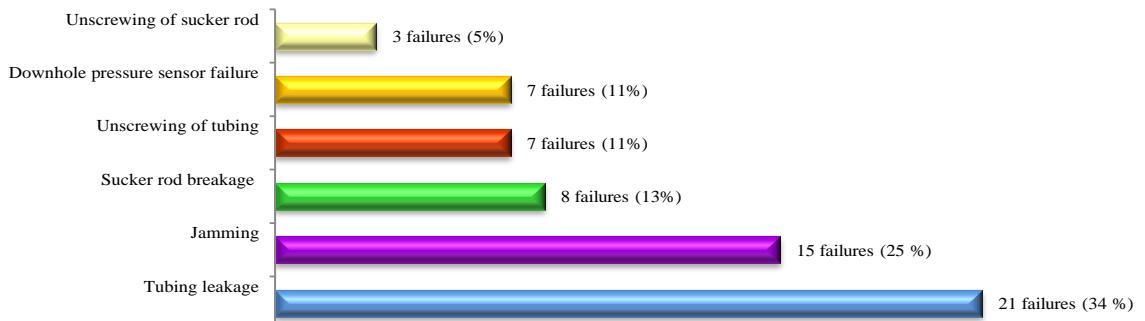


Figure 1. Distribution of sucker-rod screw pump basic components failure (on January 1, 2016).

As it can be seen from the diagram the major causes of components failure are: tubing leakage (due to the design features which were later eliminated by the increase in the number of centralizers on the rod string) and high content of mechanical impurities (proppant, coal slurry, mud) in the pumped liquid.

Electrical submersible pump units also showed good operating results. These pumps are having extended turnaround interval for CBM wells at the established operating mode.

The analysis of electrical submersible pump units exploitation for the period from 2009 to 2015 (Figure 2) has shown that operating time in 2015 on well stock was 1090 days, and the maximum operating time was 1704 days.

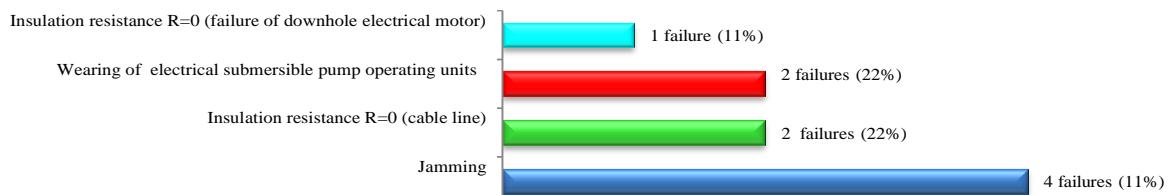


Figure 2. Distribution of electrical submersible pump units basic components failure (on January 1, 2016).

The cause of 85% of failures is the presence of the abovementioned mechanical impurities in the pumped fluid.

In 2013 balanced pumping units were introduced into CBM deposits development.

The analysis of balanced pumping units' exploitation for the period from 2013 to 2015 has shown that operating time in 2015 was 317 days on well stock, and the maximum operating time was 751 days. Only two failures occurred during the whole period of operation due to the pump plunger jamming.

4. Comparative analysis of downhole equipment economic efficiency

To evaluate the effectiveness of the three main types of downhole equipment under discussion, a comparative analysis of purchase cost, service and repair works is provided.

The results are shown in Figure 3.

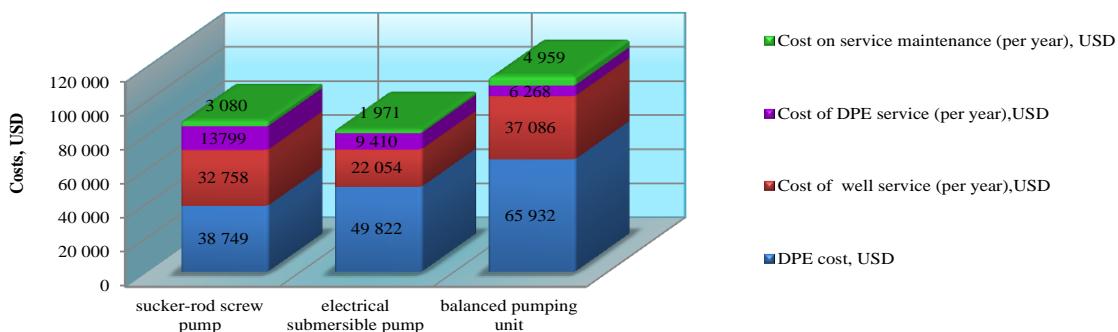


Figure 3. Correlation of downhole pumping equipment cost and costs on service and repair.

Considering the analysis of downhole pumping equipment efficiency during the development and exploitation of CBM wells and the results of cost correlation analysis, the following conclusion could be drawn:

1. The main cause of failure of all types of DPE, which were tested on wells, is the clogging of operating facilities by mechanical impurities (81%) during pumping of formation fluid, due to the fact that the developed CBM reservoirs were subjected to additional stimulation by fracturing. The first phase of development was marked by intense proppant and coal slurry lifting. This further resulted in the need of bottom-hole cleaning at each well servicing;
2. At balanced pumping unit exploitation basic costs (58%) fall on the purchase of equipment and on DPE service and repair (42%) due to the complexity of assembly work, service maintenance and the need for special service crew.
3. During sucker-rod screw pump unit exploitation the equipment purchase costs will be minimal (45%) if compared with the electrical submersible pump unit (60%), balanced pumping unit (58%) and major costs (55%) – the cost on downhole equipment service and repair.
4. During electrical submersible pump unit application, the costs on DPE service and repair are minimal (41%) due to the large turnaround interval if compared with the sucker-rod screw pump unit (56%) and balanced pumping unit (42%);
5. For operation on CBM wells, the most optimal types of downhole equipment are sucker-rod screw pump unit and electrical submersible pump unit.

In spite the fact that costs on electrical submersible pump unit and sucker-rod screw pump unit are practically the same, for more efficient exploitation it is recommended:

- At the first stage to use sucker-rod screw pump unit due to its appliance flexibility and stability of operation at the presence of high quantity of mechanical impurities in the pumped reservoir fluid;
- At the second stage on the steady-mode, under the equal conditions of exploitation (at low water inflow), it is more rational to use electrical submersible pump.

5. Economic ways to optimize costs for methane production from coal deposits

Due to the fact that an important component of success and effectiveness of project functioning is the optimal use of downhole pumping equipment and ground equipment, as well as the rational use of its

resources and the increase of its operating period, the issues related to the optimization of the equipment purchase and maintenance costs are of particular relevance.

Currently the majority of oil and gas companies implement a rental scheme (lease) of downhole equipment, which includes the provision of full range of services in equipment selection, operation, maintenance and repair:

- calculation, fitting of equipment for a definite well;
- analysis of exploitation results with the recommendations for further increase of operation rates;
- incoming control and transportation of equipment to the well (from the well);
- supervision of pumping unit installation and reaching the steady-mode of operation;
- service maintenance and repair;
- storage and safekeeping of Customers equipment.

At the same time, companies by transferring functions to the third party contractor receive the following benefits:

- absence of need to insure the property, which in its turn minimizes the tax liabilities and reduces the risks during storage and disposal of non-repairable equipment (optimization of costs for environmental protection);
- the possibility to reduce personnel maintenance costs, labor costs, insurance premiums, communication costs, transportation costs, clothing costs, certification costs, training costs, etc.;
- lack of necessity to withdraw money from circulation on purchasing oil-field equipment, thus there appears an opportunity for other projects financing, for example, new wells construction and putting into operation.

In addition, there is an opportunity for company's management team to focus on the main form of business, thus not to be distracted by non-core activities. As a result, the company reduces its capital costs.

Let's consider the case of business process transformation to outsourcing and the shifting to downhole pumping equipment rental scheme [8, 9, 10].

The major criteria, in the market monitoring process of service companies, which provide rent (lease) of DPE with complex service maintenance, are: geographical remoteness of deposit from the production bases providing rental services and equipment supply.

Calculation of rental costs was realized on the basis of commercial proposals of two companies (from Tomsk and Perm).

To determine the economic efficiency of rental scheme introduction, the results of two options were compared (Figure 4).

The first option - exploitation of wells by sucker-rod screw pump unit, purchased at company's own expense, alongside with service maintenance considering amortization period. The second option - the application of DPE rental scheme (lease) with the service maintenance provided by the contractor (Tomsk company), due to the nearest geographic location and therefore lower service costs.

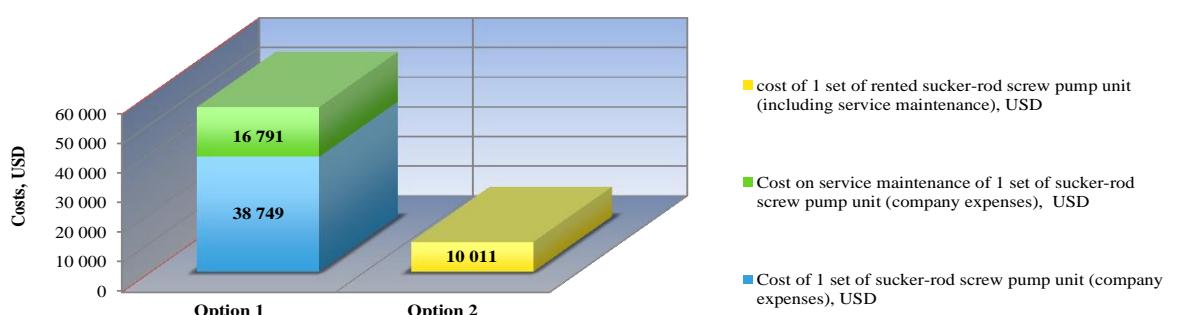


Figure 4. Cost correlation of one set of sucker-rods crew pump unit.

The following formula determines the feasibility of shifting to equipment rental scheme and the E_a design ratio:

$$E_a = \sum_{t=1}^m C_s / \sum_{t=1}^n C_r = \frac{2,516 + 0,200 + 0,896}{0,650} = 5,5 \quad (1)$$

where C_s — cost of equipment purchase and service maintenance (company expenses), USD;
 C_r — rental cost and service maintenance (contractor's expenses), USD/year.

If the designed ratio is $E_a > 1$, the outsourcing project (shifting to DPE rental scheme) will be economically efficient, and if $E_a < 1$ is economically inefficient thus, the transformation of business-process to outsourcer will not bring such economic benefit to the company as the cost cutting.

As it is seen from the calculation, the ratio is $E_a > 1$, thus outsourcing project (rent of DPE) is economically efficient.

The economic efficiency from shifting to DPE rent will be:

$$E = (C_s/A - C_r) * N = 0,554 \quad (2)$$

Where
 E — economic efficiency, USD;
 C_s — cost of 1 set of sucker-rod screw pump unit (company expenses) including service maintenance, USD;
 A — amortization period, year;
 C_r — cost of 1 set of rented sucker-rod screw pump unit (including service maintenance), USD/year;
 N — demand in DPE for the period of one year, set.

The demand for DPE for the year 2016 is 4 sets of sucker-rod screw pump units. Thus shifting to the rental scheme will bring the economic efficiency of 33 882,33 USD.

6. Conclusion

Thus, the conclusion could be drawn that in order to increase the efficiency and cost optimization in general, "Gazprom Dobycha Kuznetsk" LLC needs to select the option of shifting to DPE rental scheme with service maintenance rendered by the Contractor company and to consider the geographical remoteness.

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