Effect of Labor Management on Production Programme Implementation at a Drilling Enterprise

Garifullina Z.A.
Department of Humanities and Socio-Economic Sciences
Ufa State Petroleum Technological University,
Branch of the University in the City of Oktyabrsky
Oktyabrsky, Republic of Bashkortostan, Russia
gza96@ya.ru

Gabzalilova A.Kh.
Department of Oil and Gas Field Exploration and Development
Ufa State Petroleum Technological University,
Branch of the University in the City of Oktyabrsky
Oktyabrsky, Republic of Bashkortostan, Russia
alfiragabzalilova@mail.ru

Abstract — Production management is a system of measures that ensures harmonious development of production, implementation of new and existing equipment and other production resources, and improvement of production efficiency combining elements and production stages in space and time. Evaluation of drilling enterprise production program performance aims at identifying available reserves to be used to increase the rate of drilling operations. One of these reserves is a shorter cycle of well construction. It can be reduced by rational management of well construction. Production management requires focusing on a drilling time balance, unproductive losses of working time, since one of the main reserves for increasing the rate of drilling operations is reduction of the overhead time caused by accidents and downtime. Efficient production management is based on a number of principles: continuity, rhythm, and proportionality. To assess the performance of the production program of a drilling enterprise, we analyzed coefficients characterizing production continuity, rhythm and proportionality. Calculations showed that the continuity coefficient is 0.71, the rhythm coefficient is 98.2% and the proportionality coefficient is 0.64. The authors suggest monitoring the coefficients of continuity, rhythm and proportionality in order to optimize production management at the drilling enterprise.

Keywords — continuity, rhythm, proportionality, drilling enterprises, well construction, production organization

I. INTRODUCTION

Production management is a tool for managing the production process, regardless of the type of a finished product (goods, services, information, knowledge). To create any economic product, you need to use various resources (labor, equipment, raw materials, information and money) that are limited and rare [1]. That is why the main task of production management is effective use of these resources as well as optimal management of the employees and technological capacities by monitoring the production technology.

The well construction technology involves step-by-step performance of the following operations: site preparation, platform installation, well drilling, well testing. To assess performance of the production program of the drilling enterprise, we analyzed the coefficients of continuity, rhythm and proportionality of production [2, 3].

Table 1 shows the well construction cycle for a conditional enterprise.

| Indicator | Total, days | Including, days | Constructed wells | Cycle speed, m/c months. |
|-----------|-------------|-----------------|-------------------|-------------------------|
| 2017      |             |                 |                   |                         |
| Total cycles | 90.3       | 9.5             | 32.8              | 48.0                    | 142                      | 588                      |
| -operation | 66.6        | 9.1             | 31.6              | 25.9                    | 133                      | 798                      |
| development | 439.4      | 14.9            | 51.4              | 373.1                   | 9                        | 120                      |
| 2018      |             |                 |                   |                         |
| Total cycles | 112.1      | 13.3            | 36.9              | 61.9                    | 128                      | 474                      |
| -operation | 84.7        | 12.4            | 35.2              | 37.1                    | 118                      | 626                      |
| development | 436.6      | 25.1            | 57.1              | 354.4                   | 10                       | 126                      |

The structure of the well construction cycle is shown in Figure 1.

The well construction cycle is growing which is due to the increasing duration of the construction works. This is mainly due to organizational reasons (waiting for the crew, drilling, block removal). As can be seen from Table 2 and Figure 2, each well is idle waiting for works for 23.7 days. (including waiting for drilling - 5.8 days, waiting for development - 5.7 days, removing the block - 2.2 days, waiting for the development team - 8.5 days, well abandonment - 1.5 days) which decreases the cyclic speed by 19.4%.
TABLE II. CALENDAR TIME OF PRODUCTION WELL CONSTRUCTION

| Indicator            | Days | Days per well | Volume, % |
|----------------------|------|---------------|-----------|
| Total                | 12168| 105.8         | 100.0     |
| Construction works   | 1407 | 12.2          | 11.6      |
| repairs              | 345  | 3.0           | 2.8       |
| Waiting for drilling | 326  | 2.8           | 2.7       |
| drilling             | 4042 | 35.1          | 33.2      |
| Waiting for development | 653 | 5.7            | 5.4       |
| Block removal        | 250  | 2.2           | 2.1       |
| Waiting for the development crew | 977 | 8.5 | 8.0 |
| Development          | 2998 | 26.1          | 24.7      |
| Waiting for commissioning | 1003 | 8.7     | 8.2       |
| Well abandonment     | 167  | 1.5           | 1.4       |

According to the standard, time for well repair is 2.5 days, downtime is 2 days. The plan coefficient is

$K_c = 12.2 / (12.2 + 2.5 + 2.0) = 0.73$.

To reduce downtime of the well waiting for the development team, it is necessary to plan distribution of development teams in order to ensure strict adherence to network schedules [6].

The coefficient of continuity of well development is

$K_c = 3248 / 6048 = 0.54$.

In 2018, downtime of wells waiting for drilling and development was 653 days. Reduction of downtime when waiting for development teams will be 977 days, or 8.5 days per well. Reduction of the waiting time for commissioning up to 3.0 days per well will save 658 days (5.7 days per well).

Then the plan coefficient is

$K_c = 26.1 / (5.7 + 2.2 + 26.1 + 3.0 + 1.5) = 0.68$.

Let us calculate the coefficient of continuity of drilling production wells by formula (1)

$K_c = 84785 / 89833 = 0.94$.

Non-productive time is 6%. To reduce non-productive costs, it is necessary to minimize accidents and defects by following drilling rules.

There are three groups of organizational downtime:

- dependent on the contractor (waiting for workers, transport, tools, drill pipes, turbo-drills, cement, mud, equipment, bits, welders, etc.);
- dependent on the customer (waiting for electricity, water, orders);
- dependent on the subcontractor (waiting for grouting equipment, logging equipment).

Organizational downtime due to the fault of contractors is 2653 hours or 12.4 h per 1000 m. To reduce it, it is necessary to manage the central engineering and technological service and ensure uninterrupted supply of drilling crews.

Organizational downtime due to the fault of the customer and the subcontractor is 1061 hours or 5.0 h per 1000 m. To reduce it and cover losses, it is necessary to draw up downtime acts and file claims for compensation.

One of the ways for increasing the rate of drilling operations is to reduce unproductive time due to accidents and defects [7]. In 2018, there were 23 accidents and 1 defect at the conditional enterprise. The total time spent on elimination of accidents and defects is 2056 hours. Table 3 shows the accident rates for 2017–2018.

Fig. 2. Structure of the production well construction cycle

The degree of continuity of well construction is determined using the coefficient of continuity [4]:

$K_n = \frac{T_{tech}}{T_c}$,

where $T_{tech}$ and $T_c$ are time for technological operations and the calendar time of all works

$K_n = \frac{8697}{12168} = 0.71$.

Analysis of the coefficient of continuity shows that breaks make up 29% of the calendar time of well construction. The waiting for drilling time is 326 days, the waiting for development teams is 977 days, the well shutdown time is 653 days, the waiting for commissioning time is 1003 days, the well abandonment time is 167 days.

Despite the technological differences, the cycle elements are united by a common goal – on-time construction of the well with specified parameters. Therefore, one of the prerequisites for identifying the effectiveness of organizational options is a comprehensive analysis of all the processes [5], a detailed study of each process for improving efficiency.

The coefficient of continuity of construction works is

$K_n = 1407 / 2078 = 0.68$. 

The coefficient of continuity of development crews

$K_n = 977 / 1003 = 0.97$. 

The coefficient of continuity of waiting time for development teams

$K_n = 653 / 1003 = 0.65$. 

The coefficient of continuity of block removal

$K_n = 250 / 653 = 0.38$. 

The coefficient of continuity of development crews

$K_n = 2998 / 1003 = 2.99$. 

The coefficient of continuity of waiting time for commissioning

$K_n = 167 / 1003 = 0.17$. 

The coefficient of continuity of block removal

$K_n = 167 / 250 = 0.67$. 

The coefficient of continuity of drilling production works

$K_n = 8697 / 12168 = 0.71$. 

Let us calculate the coefficient of continuity of drilling production wells by formula (1)

$K_c = 84785 / 89833 = 0.94$. 

Non-productive time is 6%. To reduce non-productive costs, it is necessary to minimize accidents and defects by following drilling rules.

There are three groups of organizational downtime:

- dependent on the contractor (waiting for workers, transport, tools, drill pipes, turbo-drills, cement, mud, equipment, bits, welders, etc.);
- dependent on the customer (waiting for electricity, water, orders);
- dependent on the subcontractor (waiting for grouting equipment, logging equipment).

Organizational downtime due to the fault of contractors is 2653 hours or 12.4 h per 1000 m. To reduce it, it is necessary to manage the central engineering and technological service and ensure uninterrupted supply of drilling crews.

Organizational downtime due to the fault of the customer and the subcontractor is 1061 hours or 5.0 h per 1000 m. To reduce it and cover losses, it is necessary to draw up downtime acts and file claims for compensation.

One of the ways for increasing the rate of drilling operations is to reduce unproductive time due to accidents and defects [7]. In 2018, there were 23 accidents and 1 defect at the conditional enterprise. The total time spent on elimination of accidents and defects is 2056 hours. Table 3 shows the accident rates for 2017–2018.
In 2018, the number of accidents increased. The time spent on elimination of accidents increased by 28.5%, and per 1000 meters, penetrations increased from 7.1 hours to 9.6 hours. Table 4 shows that 19 out of 23 accidents are drilling tool failures caused by wear of equipment and factory defects. One accident happened due geological reasons. Elimination of this accident took 264 hours. Violation of drilling technology and negligence of workers caused two accidents.

TABLE IV. CAUSES OF ACCIDENTS AND DEFECTS

| Cause                              | 2017          | 2018          |
|------------------------------------|---------------|---------------|
| Technical, accidents per hour      | -             | 19/996        |
| Technological, accidents per hour  | 8/1600        | 2/64          |
| Geological, accidents per hour     | 1/264         |               |
| Customer fault, accidents per hour | 2/186         |               |
| Total, accidents per hour          | 8/1600        | 24/2056       |

Having analyzed the causes of organizational downtime, accidents and defects, we see that it is possible to reduce the unproductive time due to the fault of the contractor to 4259 hours or 19.9 days per well, due to the organizational downtime – to 2,653 hours (12.4 hours per 1000 meters) and due to accidents and defects – to 1666 hours (7.5 h per 1000 m).

The continuity coefficient is

\[ K_c = 30.7 / 31.3 = 0.98. \]

Under the condition that the downtime depending on the contractor will be reduced to one day or 25 days per well, the total plan continuity coefficient is

\[ K_c = 69.0 / 80.8 = 0.85. \]

The actual and plan continuity coefficients are summarized in Table 5. Actual and design-possible coefficient of continuity.

As can be seen from Table 5, the enterprise has reserves for reducing time-dependent costs. This must be taken into account when developing the production program for 2019.

II. EXPERIMENT

Rhythm means the production of the same or plan volume of products at equal intervals [8].

Production rhythm is estimated by average fluctuations of actual values of production relative to the planned value or by average values. Several indicators characterizing rhythm are used.

The initial data for solving the task are the plan and actual indicators of a monthly drilling distance presented in Table 6.

TABLE VI. IMPLEMENTATION OF THE DRILLING PLAN AT THE CONDITIONAL ENTERPRISE FOR 2018

| Month   | Plan, m | Actual, m | Variance, \(\sigma^2\) | Actual/Plan, % |
|---------|---------|-----------|------------------------|----------------|
| January | 11088   | 11037     | -51                    | 99.5           |
| February| 13526   | 12698     | -828                   | 93.9           |
| March   | 16977   | 17896     | 919                    | 105.4          |
| April   | 17300   | 18450     | 1150                   | 106.6          |
| May     | 19062   | 19108     | 46                     | 100.2          |
| June    | 17292   | 17338     | 46                     | 100.3          |
| July    | 18585   | 19961     | 1376                   | 107.4          |
| August  | 21195   | 21238     | 93                     | 100.4          |
| September| 18613  | 19356     | 743                    | 104.0          |
| October | 16258   | 17198     | 940                    | 105.8          |
| November| 21972   | 21277     | -695                   | 96.8           |
| December| 18527   | 18016     | -511                   | 97.2           |
| Total, year | 210395 | 213623     | 3228                   | 101.5          |

The fluctuation index is calculated by formula:

a) in absolute terms

\[ K_p^a = \frac{\sum d_i}{n}. \]  

b) in relative terms

\[ K_p^{rel} = \frac{\sum d_i}{\sum Q_p}, \quad d_i = Q_{ai} - Q_{pi}, \]  

where \(Q_{ai}\) and \(Q_{pi}\) are actual and plan values of the production volume in the \(i\)-th interval, m; \(n\) is the number of intervals.
Let us calculate the absolute indicator of plan implementation by formula (2):

$$K_p^a = \frac{3228}{12} = 269$$.

It shows that the monthly variance between the actual and planned indicators is 269 m, i.e., monthly over-fulfillment of the plan is 269 m.

The relative fluctuation index is calculated by formula (3):

$$K_p^{rel} = \frac{3228}{210395} = 0.02.$$  

The actual monthly plan overfulfillment is 2%.

The fluctuation indices of actual values around the average ones can be estimated in various ways. The can be calculated using the Fisher’s rhythm coefficient:

$$K_p^r = \left\{ \begin{array}{ll} 1 & \text{if } Q_a = Q_f, \text{ at } Q_a < Q_f. \\ 1 - \frac{\sum d_i}{2Q_f(1 - \frac{1}{m})} & \text{if } Q_a > Q_f. \end{array} \right.$$  

where $Q_a$ is the total actual volume of products produced for the period under study.

$$K_p^r = \left\{ \begin{array}{ll} 100 & \text{if } Q_a = Q_f, \text{ at } Q_a < Q_f. \\ 100 - \frac{2 \cdot 213623(1 - \frac{1}{12})}{3228} & \text{if } Q_a > Q_f. \end{array} \right.$$  

where $Q_a$ is the total actual volume of products produced for the period under study.

$$K_p^r = 99.2\%.$$  

Let us calculate positive and negative variances between plan and actual values using the Adamov’s rhythm coefficient:

$$K_p^{\pm} = \sum (1 - \frac{Q_a}{Q_f}), \text{ at } Q_a < Q_f. \tag{5}$$  

The coefficient of positive variance is calculated by formula (5):

$$K_p^{+} = 0.301.$$  

The coefficient of negative variance is calculated by formula (6):

$$K_p^{-} = 0.126.$$  

Total variance is calculated by formulas:

$$K_p^{\pm} = K_p^{+} + K_p^{-}, \tag{7}$$  

$$K_p^{\pm} = K_p^{+} / K_p^{-}.$$  

The coefficient of absolute total variance calculated by formula (7):

$$K_p^{\pm} = 0.301 + 0.126 = 0.427.$$  

The coefficient of relative total variance calculated by formula (8):

$$K_p^a = 0.427 / 0.126 = 2.4.$$  

The calculated indicators show that the conditional enterprise achieved the plan rhythm of the drilling work and overfulfilled the plan by 3228 m. The failure to fulfill the plan was observed in the autumn-winter period due to the climatic conditions (off-road, snowstorm, etc.).

To calculate the proportionality of production, the initial data are quarterly performance indicators of the main workshops (Table 7).

| TABLE VII. DATA ON THE WORK OF DEPARTMENTS OF THE CONDITIONAL ENTERPRISE |
|--------------------------|-----------------|-----------------|-----------------|
| Indicator                | Quarter I       | Quarter II      | Quarter III     |
| The assembly crew finishes drilling | 28              | 26              | 34              | 29              | 117 |
| Drilling crews start drilling | 23              | 31              | 36              | 31              | 121 |
| Drilling crews finish drilling | 26              | 29              | 35              | 33              | 122 |
| Well commissioning        | 21              | 30              | 32              | 41              | 124 |

The proportions of production capacity for each phase are determined in relation to the power of the leading unit (the leading phase) [9]:

$$C_i / C_0 : C_2 / C_0 : C_3 / C_0 : \ldots : C_n / C_0 = \left( P_1 : P_2 : P_3 : \ldots : P_n \right) \tag{9}$$

where $M_i$ is production capacity of the $i$-th phase, well; $M_0$ is the capacity of the leading unit, well.

The unit of the main production is a leading unit.

Using formula (9), we can find the proportion of production capacities taking the commissioning as a leading unit.

1) The proportions of production capacities for each phase is presented in Table 8.

| TABLE VIII. PROPORTIONS OF PRODUCTION CAPACITIES |
|--------------------------|-----------------|-----------------|-----------------|
| Indicator                | $K_{a1}$        | $K_{a2}$        | $K_{a3}$        |
| Quarter 1                | 28/21=1.3       | 23/21=1.1       | 25/21=1.2       |
| Quarter 2                | 26/30=0.9       | 31/30=1.0       | 29/30=1.0       |
| Quarter 3                | 34/32=1.1       | 36/32=1.1       | 35/32=1.1       |
| Quarter 4                | 25/41=1.0       | 31/41=1.0       | 33/41=0.8       |
| Year                     | 117/124=0.9     | 121/124=1.0     | 122/124=1.0     |

2) The proportionality rate is calculated by formula:

$$K_{pp} = 1 - \sum K_{mi}^{a} - K_{mi}^{0} a K_{mi}^{0}, \tag{10}$$

where $K_{mi}^{a}$ and $K_{mi}^{0}$ are calculated (optimal) and actual coefficients of proportionality of the $i$-th phase; $a$ is the correction coefficient accounting for variances between actual and optimal coefficients.

The proportionality level for each quarter and year is calculated by formula (10):

$$K_{pp} = 1 - [(1.1 - 1.3)/(1.1 - 1.1) + (1.1 - 1.1)/(1.1 - 1.1) + (1.1 - 1.0)/(1.1 - 1.0)] = 0.75;$$

$$K_{pp} = 1 - [(1.1 - 0.9)/(1.1 - 1.0) + (1.1 - 1.0)/(1.1 - 1.0) + (1.1 - 1.0)/(1.1 - 1.0)] = 0.64;$$
The strategy of production program implementation should be aimed at closing the gap between actual and plan values [10] (Table 9).

Low values of the coefficients of continuity and proportionality indicate that there are failures when implementing the production program due to poor management of well construction works. The value of these coefficients was influenced by an increase in the well construction cycle, waiting for drilling crews and the downtime of wells waiting for development crews.

In order to comply with the basic principles of production management, it is necessary to evaluate the production program of a drilling enterprise in terms of continuity, rhythm and proportionality of production at the stage of approval of the production program for the next financial year.

### III. Conclusion

The strategy of production program implementation should be aimed at closing the gap between actual and plan values [10] (Table 9).

Low values of the coefficients of continuity and proportionality indicate that there are failures when implementing the production program due to poor management of well construction works. The value of these coefficients was influenced by an increase in the well construction cycle, waiting for drilling crews and the downtime of wells waiting for development crews.

In order to comply with the basic principles of production management, it is necessary to evaluate the production program of a drilling enterprise in terms of continuity, rhythm and proportionality of production at the stage of approval of the production program for the next financial year.

### References

[1] L. Forni, M. Psiani, “Sovereign restructuring vs. fiscal adjustment in a monetary union: macroeconomic effects from model-based simulations”, Macroeconomic dynamics, vol. 22, no. 2, pp. 470–500, 2018. DOI: 10.1017/s1355667316002086

[2] M.A. Mateo-Perez, Y. Martinez-Roman, “Social ser-vices in times of economic and social crisis: the case of Spain Domenech-Lopez”, Revista de cERCETARIE SI INTERVENCION SOCIALA, vol. 50, pp. 96–110, 2015.

[3] E.R. Toro, “Do we move towards the transformation of local public administration?”, Revista gestion de las personas y tecnologia, vol. 9, no. 25, pp. 6–19, 2016.

[4] V.A. Mau, “At the final stage of the global crisis: Economic tasksin 2017–2019”, Economic issue, vol. 3, pp. 5–29, 2018.

[5] N.H. Korustova, The economic crisis in Russia and the state of the budget system, 2016.

[6] R.M. Shaidullina, A.F. Amirov, V.S. Muhametshin, K.T. Tyncherov, “Designing Economic Socialization System in the Educational Process of Technological University European”, Journal of Contemporary Education, vol. 6, no. 1, pp. 149–158, 2017. DOI: 10.13187/ejced.2017.1.149

[7] E.A. Mukhtarova, F.G. Safin, “State of modern russian youth tolerance”, European Proceedings of Social and Behavioural Sciences, vol. 50, pp. 206–213, 2018 [RPTSS 2018 – International conference on research paradigms transformation in social sciences]. DOI: 10.15405/eptps.2018.12.26

[8] R.N. Yusupov, “Resource of russian religious and philosophical tradition in constructive relationship with west”, European Proceedings of Social and Behavioural Sciences, vol. 50, pp. 1402–1408, 2018 [RPTSS 2018 – International conference on research paradigms transformation in social sciences]. DOI: 10.15405/eptps.2018.12.171

[9] V.V. Muhametshin, V.E. Andreev, “Increasing the efficiency of assessing the performance of techniques aimed at expanding the use of resource potential of oilfields with hard-to-recover reserves”, Bulletin of the Tomsk Polytechnic University. Geo Assets Engineering, vol. 329, no. 8, pp. 30–36, 2018.

[10] R.R. Kadyrov, L.S. Kuleshova, I.G. Fattakhov, “Technologies and technical devices for annual regulated flooding of a productive strata”, Advances in Engineering Research (AER), vol. 157, pp. 232–235, 2018 [International conference “Actual issues of mechanical engineering” (AIME 2018)]. DOI: 10.2991/aime-18.2018.45

### Table IX. Actual and Planned Indicators of the Production Program

| Indicator                  | Actual | Plan | Variance, % |
|----------------------------|--------|------|-------------|
| Production continuity      | 0.71   | 0.85 | 0.12        |
| construction works         | 0.68   | 0.72 | 0.04        |
| drilling                   | 0.94   | 0.98 | 0.04        |
| development                | 0.54   | 0.68 | 0.32        |
| Relative rhythm            | 0.02   | 0.00 | 0.02        |
| Fisher rhythm coefficient, %| 99.2   | 100  | -0.8        |
| Proportionality level      | 0.64   | 1.0  | -0.36       |
| Probability of program implementation | 0.64 | 1.0 | -0.36       |