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Research Article

The Risk Cost Forecast in Drilling Engineering

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Abstract: Drilling cost affects the investment benefits and program selection of drilling engineering directly. In the process of drilling, the accident time is about 3-8% of total drilling time, having a great influence on the total drilling cost. Based on analysis and adjustment of the traditional drilling engineering cost structure and the classification method, the concept of risk cost was introduced to drilling engineering cost analysis and researched the recognition and measurement of risk cost of drilling engineering, puts forward a scientific basis and analytical means for the optimization and decision-making of program design and tries to establish the theoretical research direction of drilling risk cost of our country.

Keywords: Accident probability, drilling engineering cost, risk cost

INTRODUCTION

Drilling is a complex and highly elusive systems engineering. Its fuzziness, randomness and information uncertainty determines its high risk. Drilling engineering investment heavily, sometimes single well cost could reach millions or hundreds of millions Yuan. The drilling cost directly affects the investment benefit of oil and gas exploration and development. How to shorten drilling cycle, reducing drilling risk, reducing drilling cost has always been the important research topic of modern drilling (Chen and Guan, 2000).

According to the analysis of drilling data in recent years, in the process of drilling, the non-operation production time of dispose down-hole complicated conditions and drilling accident, accounts for about 3-8% of the total drilling time, expending a huge production time, manpower and financial resources, causing the drilling cost rise. The cost of non-operation production time has a great influence on the total cost of production. The traditional drilling engineering cost focuses on the research of deterministic cost and the influence of new technology on drilling engineering cost, the cost associated with the risk is rarely studied. Undoubtedly, strengthening the measurement of the cost associated with the risk is an important way of reducing drilling cost and improving the economic benefits of the project.

Based on the traditional drilling engineering cost structure and the classification method, this study adjusted the classification method of drilling engineering cost and introduced the concept of risk cost to drilling engineering cost analysis, studied the recognition and forecast of risk cost of drilling engineering, puts forward a scientific basis and analytical means for the optimization and decision-making of program design and tries to establish the theoretical research direction of drilling risk cost of our country.

MATERIALS AND METHODS

Drilling cost structure and classification method:

Drilling engineering cost structure: Drilling engineering cost composition is very complex, involving many factors. From the perspective of engineering budget, drilling engineering cost can be divided into: material expenses, engineering service expenses, supervision and management expenses and unexpected expenses (Wang, 2006):

Material expenses: Including drilling fluid material, drilling bit, cement and other main materials expenses, equipment expenses such as casing, wellhead equipment, as well as the fuel expenses and so on.

Engineering service expenses: Including service expenses before drilling, drilling engineering expenses, well cementing expenses and logging service expenses, etc.

Supervision and management expenses: Including on-site supervision expenses, HSE expenses and management expenses, etc.

Unexpected expenses: Due to the high risk of drilling construction, as well as the information uncertainty

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caused by the lack of information, need to set aside some unexpected expenses. Especially in exploratory well, wildcat well, as no working experience in the region, without reference of adjacent well data, unexpected expenses ratio should be higher.

Drilling engineering cost classification method: The drilling cost has different classified method from different perspectives. Basically has the following kinds: fixed cost and variable cost; Rig operation cost and drilling operation cost; Cost associated with well depth and cost related to drilling time; Although there are many classification methods, the above methods is meaningless for drilling engineering costs analysis. Now the beneficial classification method for the measurement is: according with the drilling cost drivers dividing the drilling cost into two parts, cost associated with wellbore configuration and costs associated with drilling cycle (Dong and Cheng, 1994):

Cost associated with wellbore configuration: The cost has a close relationship with the wellbore configuration. According to three formation pressure profiles, confirm the factors related to the well bore structure scheme such as the borehole size, mud density, casing program, casing size and then the cost of this part is determined. Mainly includes the following parts:

- **Material expenses:** The cost of drilling fluid, drilling bit, cement and other main materials and the tubing equipment expenses such as casing and wellhead expenses
- **Engineering service expenses:** Including service expenses before drilling, drilling engineering expenses and logging expenses

Cost associated with drilling cycle: This part of the cost associated with drilling cycle (drilling time), changes with the length of the actual operation time. Mainly includes the following parts:

- **Engineering service expenses:** Logging expenses, mud service expenses, logistics service expenses (such as machine maintenance, transport service expenses), drilling engineering expenses (rig and other fixed assets depreciation expense, personnel wages; daily consume expenses such as water and electricity, fuel)
- **Tool equipment rental:** Drill operating cost, etc.,
- Supervision and management expenses

Due to the randomness of drilling engineering system process, uncertainty of information, as well as the proficiency degree of personnel operation technical, the forecast of the drilling cycle is very complex; And as the non-production time leading by bad weather, down-hole complicate conditions, accidents and test, orientation and other special operating time generated by well test and directional deflection, detail drilling time is more difficult to predict. It's meaningless to calculate the operation time of drilling engineering directly using the theory method, as error is far cry from the reality. Normally the drilling cycle forecast is adopted by probability and statistics method, through the average or weighted average calculation of the operation time of drilling in the region, get the standard work time of the operation. And then the result is the drilling cycle forecast basis of planned well.

RESULTS AND DISCUSSION

The concept of risk cost and the application in drilling engineering: Conventional drilling engineering cost structure and classification method, doesn't fully embody the cost associated with risk, only increases a percentage of unexpected expenses in the budget, existing such problems as insufficient understanding of the risk cost.

Risk cost: The concept of risk cost is put forward by the famous American insurance group RIMS's former president Douglas Barlow in 1962. The concept comes from the insurance industry in the early time and its scope is widespread, including the risk cost and risk management cost. In the late 1980s, Scott and Gregory (2005) put forward the risk cost is a concept applicable to all types of risk in their book Risk Management and Insurance. They deepen the risk cost and define its scope includes:

- The expected loss cost
- Loss control cost
- Cost of loss financing
- Internal risk control cost
- Cost of the salvage value uncertainty (Scott and Gregory, 2005)

The scope presents the characteristics of dispersion, dynamic and uncertainty of risk cost.

Risk cost in drilling engineering: Introduce the concept of risk cost into drilling engineering and it can be understood as the investment of evading and managing accident risk. Represented as:

$$C = f(R, M)$$

where,

C = The risk cost in drilling engineering
R = The monetary measurement of drilling accident
M = The monetary measurement of evading risk accident

Among it:

$$R = f(P, c)$$

where,
P = The probability of Drilling accident, %
c = The monetary measurement of drilling accident

The calculation of risk cost of drilling engineering: Traditional drilling engineering cost calculation can reflect the unexpected expenses of risk cost to some extent. Usually adopt the following formula (Hu and Zhou, 1994):

$$C_N = (C_t + C_p) * X$$

where,
C_N = The unexpected expense
C_t = The cost associated with drilling cycle
C_p = The cost associated with the wellbore configuration
X = The risk percentage (%), the more the uncertainty, the higher of the unexpected expenses percentage

But this calculation method is too simple, its subjectivity and experiential is strong and its precision is so low that far from the reality, so we have to put forward a new method.

According to the definition of risk cost, the risk cost of drilling engineering equals to:

$$C = R + M$$

where,
C = The risk cost in drilling engineering
R = The monetary measurement of drilling accident
M = The monetary measurement of evading risk accident

And,

$$R = P \cdot c$$

where,
P = The probability of Drilling accident, %
c = The monetary measurement of drilling accident

Common drilling engineering accidents and complex problems include well blowout, well stick, well leakage, well collapse, drilling tools break and down hole falling, etc. The probability of drilling accident can be calculated based on the safe drilling fluid density constraint conditions in theory now. Such as lost circulation, well kick after well shut in, well collapse, differential pressure sticking, etc., can be quantitative evaluated of multiple projects on all sections and get the accident probability value of different section, on the basis of the theory of probability and statistics (Ke, 2009).

According to the cost driver, drilling engineering accident loss can be divided into direct cost and indirect cost according to the cost cause:

Direct cost: Direct cost refers to the damage of fixed assets such as drilling equipment, facilities, tools, as well as the damage of floating assets such as materials, tubing and casualties caused by accident in drilling, such as rig, wellhead equipment, drilling bit, casing, drilling tool, drilling fluid material, etc.

Indirect cost: Indirect cost is the cost except direct cost caused by accident. Including drilling accident rescue and treatment expenses, production resume expenses (equipment repair, material purchase), time cost from accident happen to resumes normal drilling.
The formula is presented as:

$$c = c_d + c_i$$

And,

$$c_d = (l_1 - l_2) + s$$

And,

$$c_i = a + r + (t_1 - t_2) \cdot q$$

where,
c = The cost caused by drilling accident
c_d = The direct cost
c_i = The indirect cost
l_1 = The net value of fixed assets such as equipment, facilities and tools
l_2 = The salvage value of fixed assets after the accident
s = The cost of floating assets scrap and material consumption
a = The rescue and manage cost of drilling accident
r = The resume production costs (such as equipment repairing, new material purchase, etc.)
t_1 = The accident end time
t_2 = The accident occurred time
q = Unit time (drill day) expenses, the expenses including depreciation of fixed assets such as rig and equipment, additional costs such as water and electricity, fuel and other daily consumption, the cost of wages, supervision and management of related personnel

It is difficult to adopt theory method to predict the damage of drilling accident. Similar to the cost associated with the drilling cycle, we statistics the drilling accident and down hole complicated conditions in the adjacent region using the method of analogy and statistics. Through the average or weighted average method, calculate the standard cost caused by different accident in the area, then combine the accident probability, get the damage cost of drilling accident.

The forecast formula of damage cost of drilling risk accident:

$$R = \left(\frac{\sum_{j=1}^{m} c_{jk} \cdot w_{jk}}{m} \right) \cdot P$$

where,

$$c_k = \frac{\sum_{k=1}^{m} c_{jk} \cdot w_{jk}}{m}$$

$$w_{jk} = \frac{c_{jk}}{\sum_{k=1}^{n} c_{jk}}$$

where,

R = The predicted value of drilling accident damage
P = The probability of the accident
c_k = The average standard cost of accident k of the drilled adjacent well in the region
c_{jk} = The cost of accident k of well j
w_{jk} = The weight of accident k accounted in all the accidents of well j
m = The drilled well number that can be statistics in the area
n = The accident number in a single well

The cost of the measures which is taken to evade or prevent the accident in drilling, should be designed based on the experience of preventing drilling accidents and the measures which is taken in down-hole complicated conditions actually. E.g., The main technical measures to prevent and solve the sticking problem in directional well deflecting section bye slide drilling and long maintain angle section of the rotary drilling conditions includes: optimization of drilling fluid properties (density, viscosity); optimization of drilling fluid volume, improving the efficiency of carrying rock; unstuck by jar and jar accelerator; except the technical measures, management should strengthen the safety and quality supervision in the process of construction; strengthen personnel training, improving the level of construction work; improving the security of drilling engineering and scientific research, etc. Therefore, the cost of avoiding sticking accidents includes the cost of taking measures above.

CONCLUSION

- The cost of non-production time has a great influence on the total cost of drilling. The traditional drilling cost focuses on the research of deterministic cost, rarely associates with the risk cost, so strengthen the metering management related to risk cost is an important way to reduce drilling cost and improve the economic benefits.
- Conventional drilling engineering cost structure and classification method, without fully embodies the costs associated with risk, only increases a certain percentage of unexpected expenses in budget, existing several problems such as insufficient understanding of risk cost of drilling engineering, etc.
- This study introduces the concept of risk cost to the drilling engineering cost analysis, through the research on recognition and measurement of drilling risk cost, proposes drilling engineering cost measurement and forecast method, trying to establish the research direction of our country's drilling risk cost in theory.
- At present, the method to calculate drilling accident probability is based on the safe drilling fluid density constraint conditions. The risk accident that can be predicted is very limited, such as lost circulation, well kick after well shut in, well collapse, differential pressure sticking, etc. The accident or complicated situation caused by the formation characteristics and other reasons needs further study.

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