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ГЕОЛОГИЯ, ГОРНОЕ И НЕФТЕГАЗОВОЕ ДЕЛО (ДОКЛАДЫ НА АНГЛИЙСКОМ И НЕМЕЦКОМ ЯЗЫКАХ)

COMPARATIVE ANALYSIS OF PROGRAMS FOR ASSESSING THE RISK OF STUCK DRILL PIPES IN AN OIL AND GAS WELL

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In recent years, research has been carried out on the problems and solutions of drilling engineering through programs for analyzing the risks of stuck drill pipes, for instance, in Yemen, according to 2018 analysis by the SEPOC tate-owned company Safer, as seen in Figure 1, pipe stuck problems accounted for 29% of the unplanned time when drilling 206 wells; this unplanned time is 25% of the drilling time and a loss of 100.0 million dollars. Developed an engineering knowledge methodology, ME Hossain and MR Islam (2018), present several case studies to show the significance of signals identified for field applications and establish a description of the observations found before and after the problem occurred the sticking of the drill string is understood as the impossibility of lifting it out of the well under technically permissible tension or compression. Ultimate loads are limited by the strength of the material of drill pipes or other weakest elements of the string, lifting equipment, tackle equipment and derrick. The tightening of the drill string during its lifting is understood as a significant increase in the load on the hook, at which, according to technical standards, it is allowed to lift the drill string [1].

During drilling there are indications that can be related to the cause and effect of certain problems and complications, these signals occur before the failure and can be corrected before a dangerous situation; occurs and the failure can be avoided. Thus, to associate these signals with the most likely type of problem, the FMEA and ARIMA methods were used, similarly for the purpose of predicting complications based on the identified signals.

The main types of programs for analyzing the risks of stuck drill pipes are:

- Fault tree analysis
- Event tree analysis
- Failure mode and effects analysis (FMEA)
- Failure modes, effects, and criticality analysis (FMECA)
- Autoregressive integrated moving average(ARIMA) [3].

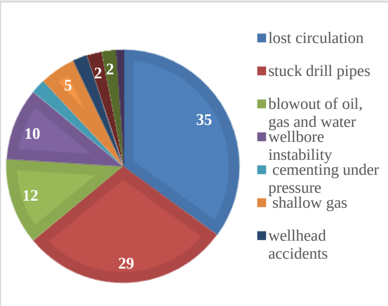

Fig.1. Distribution of well accidents in Yemen

<u>Programs analysis</u>

From the critical analysis in the table, we can say that the FMEA and ARIMA programs are effective for analyzing the possibility of errors before the different types of problems of stuck pipes while drilling. In table 1 is shown a comparative analysis of these methods for four selected indicators [4].

The estimated prices of the software for risk analysis for all methods of the companies “Kwantis” and “APIS Information’s technologies” [2].

Table 1

Comparative analysis of selected methods

Types of risk analysis program	Cost, Th $	The complexity	Applicability to the original conditions	Information update time, s
Fault tree analysis	3,5	High	Yes/for EOR	+
Event tree analysis	3,5	High	Yes/ for EOR	+
Failure mode and effects analysis (FMEA)	50,0	Low	Yes/Used	+
Failure modes, effects, and criticality analysis (FMECA)	50,0	Average	Yes/Checkout	+
Autoregressive integrated moving average(ARIMA)	14,0	High	Yes/Used	+

ARIMA has its drawbacks such as it needs a special individual programming for each filed and in case something wrong happened in programs only the ARIMA company can handle it. However, this does not mean that this model should be abandoned and only exponential smoothing models should be used in forecasting. FMEA allows more effective quality and safety of the objects at the design stage by identifying potential failures with high criticality [4].

Functional principle of FMEA method

The complications of stuck drill pipes were divided into 7 subcategories depending on the type of cause. In addition, 33 signs were identified associated with the cause and effect of certain complications. For the analysis of wells KHRIR-1-40 and KHRIR-1-34, 12 indicators were assessed, associated with the type of stuck pipes due to unconsolidated formations and due to sedimentation of cuttings. These indicators identified attributes allow the selection of the drilling parameters most associated with the problem (ROP, WOB, torque and RPM) and were analyzed using the ALEX DRILLING office model. Two predictions were made: the green line is the optimal behavior that the well should have based on the historical data of the KHRIR-1-34 well, where it was in the past, and the red line predicts the expected behavior of the KHRIR-1-40 well. The differences between the predicted values for the ROP have been calculated to determine the extent to which these changes should be precautionary and take necessary action. Changes in the values of the two predictions determine the level of risk, for example, for ROPs, when values greater than 3 are observed, corrective action must be taken as this poses a high risk, when values are in the range of 1 to 3, preventive action must be taken and values less than 1 do not pose a significant risk [4,5]

Table 2

ROP deviation calculation

			Prediction		Changes
Steps	Время (min)	ROP fact	ROP self-correcting.	ROP c25	
5.5	30	36.1	38.1	38.8	1.02
26	60	31.4	38.1	39.3	1.03
26.5	90	37.3	38.1	39.6	1.04
27	120	42.8	38.1	39.8	1.04
27.5	150	29.4	38.1	39.9	1.05
28	180	30.5	38.1	40.0	1.05
28.5	210	31.6	38.1	40.0	1.05
29	240	32.7	38.1	40.1	1.05
29.5	270	22.3	38.1	40.1	1.05
30	300	10.7	38.1	40.1	1.05
30.5	330	10.7	10.7	40.1	3.75
31	360	10.6	10.7	40.1	3.75
31.5	390	10.5	10.7	40.1	3.75
32	420	10.4	10.7	40.1	3.75
32.5	450	11.6	10.7	40.1	3.75
33	480	13.2	10.7	40.1	3.75
33.5	510	16.9	10.7	40.1	3.75
34	540	21	10.7	40.1	3.75
34.5	570	25	10.7	40.1	3.75
35	600	29.1	10.7	40.1	3.75
35.5	630	13.8	30.2	40.1	1.33
36	660	19.4	31.2	40.1	1.29
36.5	690	20.1	31.9	40.1	1.26
37	720	18.4	32.5	40.1	1.23
37.5	750	16.7	33.1	40.1	1.21
38	780	17.8	33.5	40.1	1.20
38.5	810	21.3	33.8	40.1	1.19

Table 3

Risk alerts

Risk level		
calculated change	low	middle
ROP	< 1	1 - 3
TORQUE	< 0.96	0.96 -1.05
INCL	< 0.9	0.9 - 1

Thus, it is possible to create alarms and predict the level of risk every 30 minutes in order to avoid problems with stuck pipes.

Structural cause and effect relationships were created for each of the traits, these relationships are quantified based on severity, appearance and detection using the FMEA method. Application of the FMEA method and ARIMA model can reduce the risk of pipe sticking, which will reduce the unplanned drilling time for the well KHRIR-1-40 by 63% (451 hours) and save more than one million dollars in unplanned downhole time.

It can be concluded that it is more profitable for drilling companies to purchase the FMEA method, since, despite the fact that it can be used more expensively at all of the company's fields, instead of the ARIMA model, it is more economical, but it must be purchased for each field for which it will be implemented. Both methods reduce the risk of sticking problems, which can save the company $ 1,658,633.68 over two years of use [4].

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PREDICTING THE YIELD OF TARGET PRODUCTS AND COKE FROM THE CATALYTIC CRACKING PROCESS UNDER CONDITIONS OF VARYING FEEDSTOCK COMPOSITION

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Catalytic cracking is considered one of the main processes in the refining industry for the production of high quality components for motor fuels and rich in propane-propylene and butane-butylene fractions wet gas. Currently, catalytic cracking involves various raw materials (vacuum and atmospheric gas oils, heavy residues of secondary refining processes, etc.), depending on the type of which, the technologies and process catalysts differ significantly. The processing of heavy feedstock with a high content of aromatic hydrocarbons, resins and heavy metals leads to an increase in the amount of coke formed on the catalyst surface, thereby affecting the heat balance of the "lift-reactor-regenerator" system and, as a consequence, to the formation of a low yield of gasoline fractions and gas. Thus, to simulate the process adequate, mathematical models should take into account the constantly changing group composition of the processed raw materials [1]. At the same time, the creation of an adequate model of catalytic cracking is complicated by the difficulty of identifying groups of hydrocarbons and the lack of analyzes to determine the group composition of feedstock in refinery laboratories. Thus, the development of a methodology for the relationship of such parameters as regular physical properties (fractional composition, density, viscosity) with the component composition of feedstock is relevant.

The purpose of this work is to develop an algorithm for calculating the group composition of vacuum gas oil based on its physical properties and to study the effect of the group composition of feedstock on the yield of target products and coke in catalytic cracking technology using a mathematical model of the process.

As a result of the performed numerical and experimental studies, a method was developed for calculating the group composition of vacuum gas oil based on the relations between the physical parameters of oil product [2]. The calculation error does not exceed 3%. The empirical formulas for determining the molecular weight and refractive index used in the calculation take into account the degree of paraffin content of fraction [3]:

$$MW = (7K - 21{,}5) + (0{,}76 - 0{,}04K)T_{av.m.} + (0{,}0003K - 0{,}00245)T_{av.m.}^2$$

$$\mathrm{n_D^{20}} = 2{,}1500 - 10^{(\lg\mathrm{MW} - 1{,}9939436 - 0{,}0019764 * T_{av.m.})},$$

where MW – molecular weight of fraction, g/mol., n_D^{20} – refractive index of fraction at 20 °C, $T_{av.m.}$ - average molar boiling point, °C; K - characteristic factor:

$$K = \frac{1{,}216\sqrt[3]{T_{av.m.}}}{\rho},$$

where $T_{av.m.}$ - average molar boiling point, °K; ρ – density of fraction at 15 °C, g/cm^3.

The developed technique is based on a system of three equations:

$$\begin{cases} x_p + x_N + x_{A+R} = 1 \\ 1{,}048 \cdot x_p + 1{,}03 \cdot x_N + 1{,}07 \cdot x_{A+R} = Ri \\ 0{,}74 \cdot x_p + 0{,}89 \cdot x_N + 0{,}95 \cdot x_{A+R} = VGC \end{cases}$$

The first equation is the molar balance of the group composition of vacuum gas oil, the second and third equations are additive law for refractivity intercept (Ri) and viscosity gravity constant (VGC). Determination of the group composition of heavy fractions on the basis of viscosity gravity constant and refractivity intercept was proposed by the authors in [4]. The