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ANALYSIS OF OIL FIELD EQUIPMENT CONDITION IN THE PROCESS OF EXPLOITATION

INTRODUCTION

For the last years there has been discovered a wide application of methods enabling to describe processes in composite systems with the help of known notions and models. Thus under analysis of dynamic systems the results, which have long ago become classic in other spheres are worth close attention. On this grounds some common regularities at diagnosis of engineering systems can be worked out.

PREVIOUS DATA RETRIEVAL TECHNIQUES

For example, technical availability condition of drilling and oil field equipment can be diagnosed indirectly via time series graphs of samplings removed under different conditions of exploitation installations (of fluid pressure, bit thrust loads, and rotor torque). Thus the usage of time series measurements of these samplings (spectral - correlation analysis, theory of ejection beyond the established level of correlation dimensionality [1, 2]) can be viewed upon as diagnostic criteria, defining state of the installations analyzed.

PROPOSED METHOD

During equipment condition evaluation great attention should also be paid to a degree of uncertainty of this or that state approaching. Taking this fact into consideration, it is offered to use analysis of entropy modification (Э), which is a measure of indeterminacy of an aleatory a new criterion for diagnosis of handling time series of samplings.

If the finite set {x1, x2, …, xn} of values of an aleatory variable with a probability distribution {P1, P2, …, Pn} is preselected, the entropy of allocation (Pi) will make:

$$Э = -\sum P_i \cdot \log P_i \, . \qquad (1)$$

As implies from equation (1), the growth of entropy is functionally bound to the growth of state probability. And the entropy ascending in irreversible process means state probability ascending

The array of statistic data for definition of an entropy index and diagnosis of the analyzed equipment was obtained from the data, given by an automated drilling parameter station located in Western Siberia. The analysis of index modification of entropy pressure ($Э_P$) and loading entropy ($Э_G$) in accordance with well deepening has shown, that this dependence carry vibratory nature, which hampers traditional methods

of application of its interpretation. It's complicated enough to determine the moment of equipment transformation from one state to another by entropy. Certain regularities were determined after introduction of the following diagnosing criteria:

$$\Phi_P = Э_{2P}/Э_{1P}, \quad \Phi_G = Э_{2G}/Э_{1G}, \qquad (2)$$

where Φ_P - criterion of equipment work capacity on pressure;
Φ_G - criterion of equipment work capacity on loading;
Index 1 - good working condition (initial) state of equipment;
Index 2 - limiting (current) state of equipment.

On table 1 there is as an example of the calculated results of entropy index and working capacity criterion of a drilling bit at Samotlorsky field borehole №18061. Fig. 1 and 2 shows modification of criteria of diagnosing depending on well depth and magnification of bit life coefficient for all determined for all wells of well cluster №849. As analysis has shown, on the initial stage of equipment exploitation the modification criteria of diagnosing are unessential, but they tend to augment depending on well sinking and impairment of a bit availability index.

Table 1 - Calculated entropy "Э" results and criteria of a bit work capacity "Φ" depending on a bit availability index at borehole №18061 drilling.

Drilling interval, m	Entropy index at starting point of drilling		Entropy index at final point of drilling		Work capacity index: $\Phi_P = S_{2P} / S_{1P}$, $\Phi_Q = S_{2Q} / S_{1Q}$.		Bit wear index
	$Э_{1P}$	$Э_{1G}$	$Э_{2P}$	$Э_{2G}$	Φ_P	Φ_G	
425-575	8,70	5,88	8,53	5,67	0,98	0,96	$В_1П_1$
575-1194	6,14	5,72	7,35	6,80	1,19	1,18	$В_2П_2$
1194-1528	6,88	6,09	9,12	8,56	1,32	1,40	$В_4П_2$
1528-1720	6,14	6,61	8,19	8,90	1,21	1,34	$В_3П_2$

The maximum results of diagnosing on a well cluster №849 at different bit availability indices have compounded:

minimum wear ($В_2П_1$) - Φ_P = 1.19, Φ_G = 1,18;
medium wear ($В_3П_2$) - Φ_P = 1.21, Φ_G = 1,34;
maximum wear ($В_4П_2$) - Φ_P = 1.32, Φ_G = 1.40.

The criteria dimensions Φ_P=1,32 and Φ_G=1,40 can be accepted as standard and at subsequent exploitation of the reviewed equipment in similar mining-geological conditions they ought to be sustained in limits $\Phi_P \le \Phi_P^{st}$ and $\Phi_G \le \Phi_G^{st}$.

Thus, let us presume, that prior to drilling the bit is in an equilibrium, in a particular time interval the availability index of the bit will vary, that will reduce in disequilibrium of a system ascending both fluid pressure entropy and loading. Therefore, at bit diagnosing during its exploitation it is necessary to sustain work

capacity criteria dimensions (Φ) at a particular level not exceeding standard dimensions, that is bound to prevent accidents on a bit.

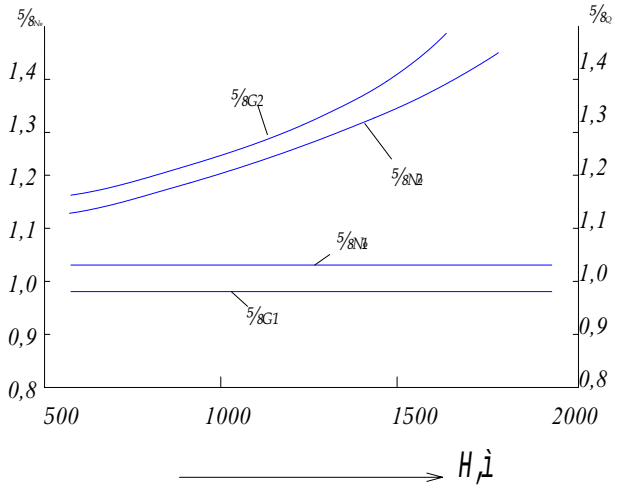

Figure 1 - Modification of work capacity criteria of bit depending on its availability index in the process of well drilling (1 - new bit, 2 - worn bit)

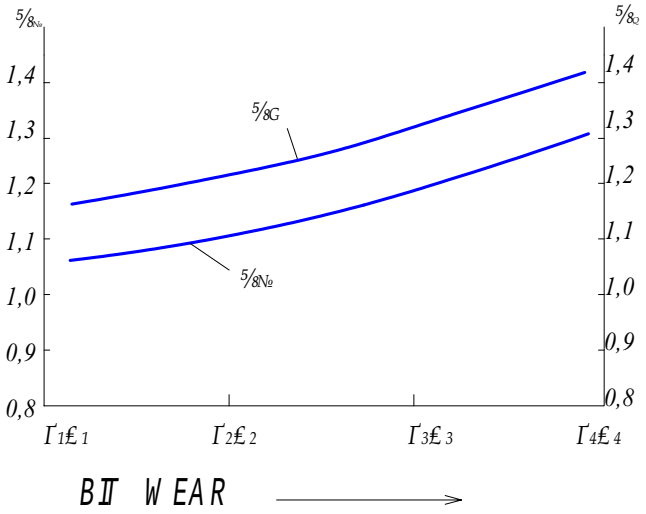

Figure 2 - Modification of work capacity criterion depending on increase its wear extent

The proposed entropy criteria supplement other methods of indirect machinery state estimation and being applied to them can increase efficiency of accepted technological solutions. It is possible to refer coefficient Jinny, used in economy [4] to the group of criteria for indirect machinery state estimation.

The algorithm of Jinny coefficient definition includes Lorentz curve or allocation line plotting. For this purpose the dependence of parameters, taken in well drilling process (oscillation of pressure of oscillations of thrust load on a bit (Y)) on an

amount of these values at the beginning and at the end of every drilling (X) is displayed on fig. 3. If there was an absolute equality between measuring of drilling process parameters and modification of bit availability index, then, for example, 20% bit wear would correspond only to one dimension of parameters, 40% wear - to other dimension, etc., that is reflected by OE curve of fig. 3. Actually, there is quite another dependence, reflected by OABCDE curve or the so-called curve of Lorentz. The more deviation of Lorentz curve from line OE can be traced, the less correlation between analyzable indices can be found. The square of a figure ABCDEO is an integrated index of difference between real allocation from completely uniform one.

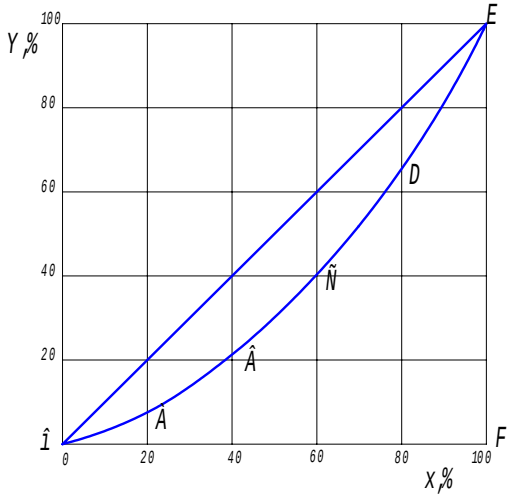

Figure 3 - Definition of Jinny coefficient
X - quantity of aleatory variable values;
Y - numeric dimensions of aleatory variable.

For definition of coefficient Jinny it is necessary to split square S1 between segment OE and Lorentz curve into square S2 of a triangle OFE:

$$D = S_1 / S_2 . \qquad (3)$$

Under the above mentioned method there have been defined the data of Jinny coefficient according to results of ten wells drilling at Samotlorsky field borehole №849 , where 55 bits with different coefficient of wear are used. On fig. 4 and 5 concrete examples of Jinny coefficient definition on two parameters measured in well drilling process are shown. It is obvious from the charts, that the worse the bit condition is, the more obvious the deviation of the real curve from the uniform distribution curve is. For determination of correlation between Jinny coefficient and modification of a bit condition, we shall introduce the following indexes:

$$\begin{cases} T_P = 1 - D_P \\ T_G = 1 - D_G \end{cases}, \qquad (4)$$

where T_P – work capacity on fluid pressure index,

T_G –work capacity on thrust load index,

D_P, D_G – Jinny coefficients of oscillations according to fluid pressures and thrust loads.

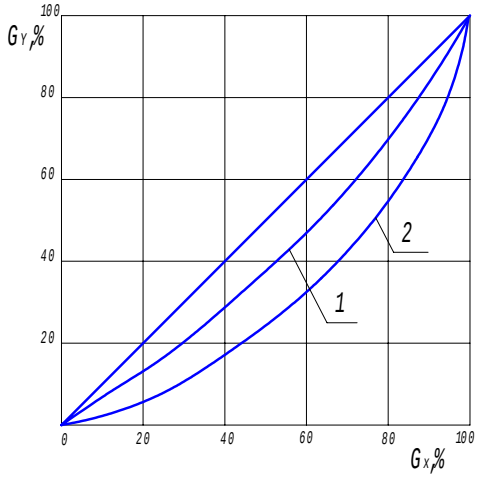

Figure 4 - Definition of Jinny coefficient by oscillations of axle load on bit weights under different conditions of the tool
1 - minimum bit wear (В2П1)
2 - maximum bit wear (В3П3)
well № 30568, spacing - 413-1047м

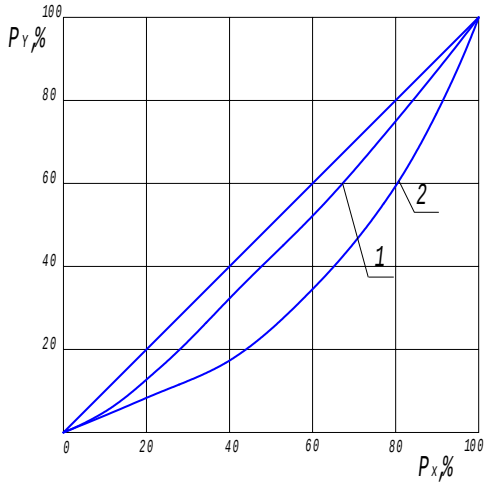

Figure 5 - Definition of Jinny coefficient on oscillations of flush fluid pressure at different states of the tool
1 - minimum bit wear (В1П1)
2 - maximum bit wear (В4П3)
Well № 30568, spacing - 1583-1752м

The analysis of the obtained outcomes has shown (fig. 6), that the minimum wear of arms (B1) and bearing of a bit (П1) corresponds to a modification of criteria TP in limits 0,996 … 0,989 and TG - 0,956 … 0,950.

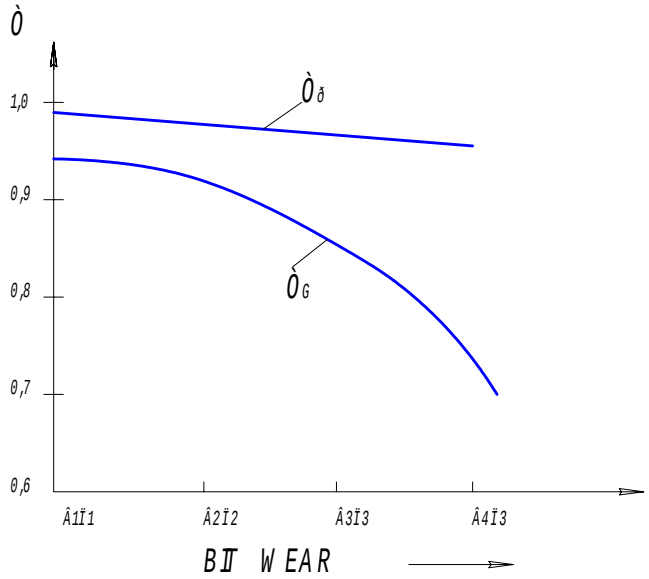

Figure 6 - Modification of bit work capacity criteria according to increase of an extent of its wear

In accordance with a bit wear increase the work capacity indices are moderated in following limits:

at В2П2 TP = 0,986 … 0,981, TG = 0,924 … 0,905;
at В3П3 TP = 0,979 … 0,967, TG = 0,838 … 0,811;
at В4П3 TP = 0,960 … 0,933, TG = 0,769 … 0,697.

Therefore, as standard dimensions for diagnosing it is accepted TP = TG = 1, that corresponds to a new bit parameters. At cluster well drilling the magnitude of a standard TP and TG value criteria can be determined by results of a pioneer well drilling after 5-6 series done by considerably worn bits. At further drilling the current value of a bit work capacity criterion is inspected, and its deviation from accepted standard values is not permitted.

CONCLUSIONS

The designed modes of a bit entropy and Jinny coefficient diagnosing can find application in the automated systems of drilling parameters measuring, and also in other areas, where estimation of technical condition control is carried out by measuring of stochastic process oscillations.

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