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PROCESSING SYSTEM OF DYNAMOMETRICAL DATA ON THE BASIS OF MODERN INFORMATION TECHNOLOGY

Telman Aliev[1], Gambar Guluyev[2], Asif Rzayev[3],
Farhad Pashayev[4], R.Malikov[5], I.Yusifov[6]

[1-5]Institute of Cybernetics of ANAS, Baku, Azerbaijan, [1]*telmancyber@yahoo.com*,
[2,3]*scb_06@mail.ru*, [4]*farhad_pasha@mail.ru*, [5]*mrasim@mail.ru*
[6]Shirvanoil BMMM, Shirvan, Azerbaijan, *iltizam.yusifov@shirvanoil.com*

The proposed system forms decisions on complex processing of dynamometrical data and consequently on

- the condition of surface and underground equipments;
- the operation condition;
- correction of the operation condition

of the wells exploited by the application of sucker-rod depth pump on the basis of modern information technologies. The system creates, corrects Well-Data Base containing necessary data on a well and pump and functions on the basis of this base.

The Well-Data Base is included necessary data as:

- date of drilling of a well;
- depth and perforation depth;
- lowering depth of a pump;
- diameter of the pump;
- characteristics of auger string;
- move in the point where the auger string is hung;
- number of revolutions;
- productivity of a well;
- type of well controller;
- types of primary dynamometrical data converters;
- automatic control level of a well;

The dynamometer cards obtained from a well are stored in the Base of Historical Dynamometer Cards, Etalon dynamometer cards and Current dynamometer cards.

The system solves the following problems:

1) Definition of information content to be obtained from the well by making use of the primary data collected from the passport conditions of the well and about a well (how many periods of the pump work should the data cover). System makes information content more exact during the work process and gives opportunity to change the information content by an operator (technologist). During specifying information content

- lowering depth of a pump;
- number of revolutions;
- productivity of a well and potential productivity of a pump;
- probability of existence of gas factor and etc.

is taken into consideration.

2) definition of the statistical characteristics of noise-like (obstacles) components , which give opportunity to determine the beginning of changes in the condition of surface and underground equipments of a well in the composition of data ([1], page 138)

The signals obtained from primary dynamometrical information providers may be described as

$$g(i\Delta t) \approx x(i\Delta t) + \varepsilon(i\Delta t) \qquad (1)$$

Here x shows the wanted signal and ε - obstacles.

$$\varepsilon''(i\Delta t) = \overset{0}{g}(i\Delta t)\overset{0}{g}((i+1)\Delta t) + \overset{0}{g}(i\Delta t)\overset{0}{g}((i+3)\Delta t) - 2\overset{0}{g}(i\Delta t)\overset{0}{g}((i+2)\Delta t)$$

$$\varepsilon'(i\Delta t) = \overset{0}{g}{}^{2}(i\Delta t) + \overset{0}{g}(i\Delta t)\overset{0}{g}((i+2)\Delta t) - 2\overset{0}{g}(i\Delta t)\overset{0}{g}((i+1)\Delta t)$$

$$\overset{0^*}{\varepsilon}(i\Delta t) \approx \operatorname{sgn}\left[\varepsilon'(i\Delta t) - \varepsilon''(i\Delta t)\right]\sqrt{|\,\varepsilon'(i\Delta t) - \varepsilon''(i\Delta t)\,|}\,\varepsilon \qquad (2)$$

$$m_{\varepsilon} = \begin{cases} \dfrac{1}{N}\sum\limits_{i=1}^{N} \operatorname{sgn}\ \varepsilon'(i\Delta t)\sqrt{\left|\varepsilon'(i\Delta t)\right|} & ;\ \mathrm{r}_{x\varepsilon} = 0 \\ \dfrac{1}{N}\sum\limits_{i=1}^{N} \operatorname{sgn}\ \left[\varepsilon'(i\Delta t) - \varepsilon''(i\Delta t)\right]\sqrt{\left|\varepsilon'(i\Delta t) - \varepsilon''(i\Delta t)\right|} & ;\ \mathrm{r}_{x\varepsilon} \neq 0 \end{cases}$$

$$D_{\varepsilon} = \begin{cases} \dfrac{1}{N}\sum\limits_{i=1}^{N} \varepsilon'(i\Delta t) & ;\ \mathrm{r}_{x\varepsilon} = 0 \\ \dfrac{1}{N}\sum\limits_{i=1}^{N} \left[\varepsilon'(i\Delta t) - \varepsilon''(i\Delta t)\right] & ;\ \mathrm{r}_{x\varepsilon} \neq 0 \end{cases}$$

$$R_{x\varepsilon}(\mu) = \begin{cases} \dfrac{1}{N}\sum\limits_{i=1}^{N}\left[g(i\Delta t) - \operatorname{sgn}\varepsilon'(i\Delta t)\sqrt{\left|\varepsilon'(i\Delta t)\right|}\right]\operatorname{sgn}\varepsilon'(i\Delta t)\sqrt{\varepsilon'(i\Delta t)}; & r_{x\varepsilon} = 0 \\ \dfrac{1}{N}\sum\limits_{i=1}^{N}\left[g(i\Delta t) - \operatorname{sgn}\left[\varepsilon'(i\Delta t) - \varepsilon''(i\Delta t)\right]\sqrt{\left|\varepsilon'(i\Delta t) - \varepsilon''(i\Delta t)\right|}\ \right]\times & \\ \times\operatorname{sgn}\left[\varepsilon'(i\Delta t) - \varepsilon''(i\Delta t)\right]\sqrt{\varepsilon'(i\Delta t) - \varepsilon''(i\Delta t)} & ;\quad \mathrm{r}_{x\varepsilon} \neq 0 \end{cases}$$

$$r_{x\varepsilon} = \frac{R_{\overset{0}{x}\overset{0}{\varepsilon}}(0)}{\sqrt{R_{\overset{0}{x}\overset{0}{x}}(0)R_{\overset{0}{\varepsilon}\overset{0}{\varepsilon}}(0)}} = \frac{R_{\overset{0}{x}\overset{0}{\varepsilon}}(0)}{\sqrt{D_x D_{\varepsilon}}} = \frac{1}{N}\sum_{i=1}^{N}\left[\left[g(i\Delta t) - \operatorname{sgn}\left[\varepsilon'(i\Delta t) - \varepsilon''(i\Delta t)\right]\sqrt{|\,\varepsilon'(i\Delta t) - \varepsilon''(i\Delta t)\,|}\right]\right]\times$$

$$\operatorname{sgn}\left[\varepsilon'(i\Delta t) - \varepsilon''(i\Delta t)\right]\sqrt{|\,\varepsilon'(i\Delta t) - \varepsilon''(i\Delta t)\,|}\times$$

$$\left\{\left[\frac{1}{N}\sum_{i=1}^{N}\left[\left[g(i\Delta t) - \operatorname{sgn}\left[\varepsilon'(i\Delta t) - \varepsilon''(i\Delta t)\right]\sqrt{|\,\varepsilon'(i\Delta t) - \varepsilon''(i\Delta t)\,|}\right]^{2}\right]\times\left[\frac{1}{N}\sum_{i=1}^{N}\left[\varepsilon'(i\Delta t) - \varepsilon''(i\Delta t)\right]\right]\right]\right\}^{\frac{1}{2}}$$

3) Smoothing by the application of the methods of classic and separation of obstacles of information.

$$x^{0}(i\Delta t) \approx g^{0}(i\Delta t) - \varepsilon^{0^*}(i\Delta t)$$

obtained from (1)-(2) formulas would be smoothened. ([1] page 165)

4) Construction of surface dynamometer cards and plunger dynamometer cards

$$P=F(t), \quad U= F(t), \quad P = F(U)$$

U – displacement in any section of auger string;
X – coordinate of controlled section;
t – time;
a – velocity of sound propagation in rod material;
f – area of cross-section;
E – module of tension;

$a = \sqrt{\dfrac{E}{\rho}}$, *if b-* friction *(size = sc)* is constant then oscillation equation of auger string is

$$a^2 \cdot \frac{\partial^2 U}{\partial X^2} = \frac{\partial^2 U}{\partial t^2} + b\frac{\partial U}{\partial t}.$$

Limit conditions: displacement and force in the point where the auger string is hung

$$U_{x=0} = U(t);$$

$$\frac{\partial U}{\partial X}_{x=0} = -\frac{1}{E \cdot f} \cdot P(t)$$

Solution of the problem for any l distance gives opportunity to construct plunger dynamometer card.

$$U_1(t) = \frac{1}{2}\left[U(t+\frac{l}{a}) \cdot e^{\frac{1}{2}\frac{bl}{a}} + U(t-\frac{l}{a}) \cdot e^{-\frac{1}{2}\frac{bl}{a}}\right] - \frac{1}{2}\frac{a}{Ef}\int_{-\frac{l}{a}}^{\frac{l}{a}} P(t+\tau)e^{\frac{1}{2}b\tau}d\tau;$$

$$P_1(t) = \frac{1}{2}\left[P(t+\frac{l}{a}) \cdot e^{\frac{1}{2}\frac{bl}{a}} + P(t-\frac{l}{a}) \cdot e^{-\frac{1}{2}\frac{bl}{a}}\right] - \frac{1}{2}\frac{Ef}{a}\left[V(t+\frac{l}{a})e^{\frac{1}{2}\frac{bl}{a}} - V(t-\frac{l}{a})e^{-\frac{1}{2}\frac{bl}{a}}\right] -$$
$$-\frac{1}{4}b \cdot \frac{Ef}{a}\left[U(t+\frac{l}{a})e^{\frac{1}{2}\frac{bl}{a}} - U(t-\frac{l}{a})e^{-\frac{1}{2}\frac{bl}{a}}\right];$$

$$V_1(t) = \frac{1}{2}\left[V(t+\frac{l}{a}) \cdot e^{\frac{1}{2}\frac{bl}{a}} + V(t-\frac{l}{a}) \cdot e^{-\frac{1}{2}\frac{bl}{a}}\right] - \frac{1}{2}\frac{a}{Ef}\left[P(t+\frac{l}{a})e^{\frac{1}{2}\frac{bl}{a}} - P(t-\frac{l}{a})e^{-\frac{1}{2}\frac{bl}{a}}\right]$$
$$+\frac{1}{4}b \cdot \frac{a}{Ef}\int_{-\frac{l}{a}}^{\frac{l}{a}} P(t+\tau)e^{\frac{1}{2}b\tau}d\tau;$$

Algorithms are given for computer solution ([2], page 213).

5) Definition of filling percentage and momentary productiveness (for one or several revolutions)

System specifies the coefficient of correctness of momentary productiveness comparing momentary productiveness with Etalon metering. The results of momentary productiveness and Etalon metering are stored at Well-Data Base.

6) Storage of dynamometer cards in Current Dynamometer Cards Base. Storage of Current Dynamometer Card in Etalon Base of Dynamometer Card by the instruction of operator; Storage of different dynamometer cards in the Base of Historical Dynamometer Cards. System can visually show how the condition of surface and underground equipments of wells change by showing the dynamometer cards in the Bases of Current, Etalon and Historical Dynamometer Cards.
7) Diagnostics of the technical condition of surface and underground equipments of a well. For diagnosing the technical condition of surface and underground equipments of a well the vector of diagnostic signs are formed by making use of both classic methods and modern information technologies, particularly analyzing of special obstacles and binary technologies. Current condition is compared with etalon conditions and as a result a diagnostic decision is formed. The following decisions may be formed:

- gas factor is determined in a well;
- the lower part of the plunger beats;
- the upper part of the plunger beats;
- there is a danger of sandy cork;
- oil pipes floats;
- the pump valves floats;
- at which distance the rod was broken and etc.

8) Changing of operation conditions. In addition to diagnostic decisions the system passes decisions on the changing of operation conditions, as well.

- to change the number of revolutions. System carries out this decision itself if the wells are equipped with equipments of "Unidevr" type;
- to increase the lowering depth of a pump;
- to pass the well into periodical operation. System may carry out this decision itself if the wells are equipped with corresponding equipments.
- To keep a well for repair.

Literature

1. Telman Aliev. Digital Noise Monitoring of Defect Origin. Springer (2007) 223 p.
2. T.M. Aliyev and etc. Automatic control and diagnostics of borehole rod pumping facilities (in Russian). Nedra (1988) 230 p.