BAYES DIAGNOSING HYDRATOFORMATION IN GAS COLLECTION LOOPS AT THE SUFFICIENT APRIORISTIC INFORMATION

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1. Introduction

The gas collection loop represents the pipeline with which help crude gas from an extraction place (a bush of chinks) before installation of its complex preparation is transported. On deposits with severe weather conditions (-30^0) what northern areas of Russia, in particular Arkhangelsk, Sverdlovsk, Perm, Tyumen, Norilsk, Urengoy, Kamchatka, northern areas of Kazakhstan, etc. in loops occurs hydratoformation (HF). ГО in loops, changing their characteristics, leads to loss of potential energy of gas, increase in industrial expenses and decrease and even the termination (at formation of an ice stopper) gas transportations. Last case is considered emergency which elimination creates the big problems connected with essential economic and time losses. Thereupon the question of timely diagnosing HF and its preventions is represented actual. In the gas enterprises for prevention HF in head and in some cases in intermediate parts of a loop submit a special liquid - метанол which makes the basic part of expenses in gas transportation. Under production conditions the quantity variation метанола manages to be operated HF and to support it in admissible limits. Proceeding from it the problem of management HF is formed. Such management in existing practice, in the absence of qualitative model, is carried out by the person, (operator) making the decision, proceeding from the store of knowledge. Thus for care support enough the big expense metanol in a loop, that often leads to essential economic losses.

2. Problem statement

The diagnosing problem consists in definition on operatively - to measured signs of condition HF in loops. In many cases because of complexity and economic inexpediency of direct measurement of signs HF, in practice use indirect signs easily accessible to measurement, in particular, operatively - measured values of temperature t and pressure p gas in the end of a loop (at an input in a collector of installation of preparation of gas). These sizes we will designate a vector $x = (x_1, x_2)$ where x_1 - temperature, and x_2 - pressure of gas in the end of a loop. Set of possible values x we will designate through X.

In existing practice it is frequent instead of measured values of temperature and pressure use their values corrected on certain formulas taking into account a number of characteristic indicators of gas and a loop. With that end in view widely use well-known Shuxov's formula taking into account Thomson-Wilson's effect.

The considered problem dares in two stages more low.

1. Classification of conditions HF, i.e. splitting of set X into subsets X_j corresponding to various conditions HF. In practice for diagnosing HF use two subsets of conditions HF. Normal and abnormal - inadmissible. Such two-alternative representation of a condition HF is rigid, reflects its properties insufficiently, proceeding from it we enter an additional intermediate subset which reflects abnormal, but tolerant conditions HF. Thus in the approach offered by us, unlike traditional, the number of conditions makes three. Such three-alternative representation of set X promotes considerable decrease in risk at decision-making on condition. These sets we will designate through $X_1 ... X_2, X_3$.

At known number of subsets of conditions HF the classification problem consists in definition of functions dividing them. At the decision of this problem that there is a sufficient aprioristic information (statistics) about x here is accepted.

2. Diagnosing of condition on current measurements x. The problem of this stage consists in definition of a rule of recognition of condition HF on operatively measured x and decision-making on reference of the measured value x to one of subsets.

It is necessary to notice, that from problems of the specified stages of the most difficult the problem of the first stage is represented, especially at a priori unknown number of subsets of conditions ГО.

In existing to practice of diagnosing of condition HF dividing functions are defined unequivocally expert by. Thus each subset is represented two-place characteristic function, that considers the importance of separate elements of corresponding subsets insufficiently. Proceeding from it, in [1] suggest subsets of conditions HF to represent in the form of the indistinct sets described by multiple-valued characteristic functions (accessory functions). It is proved by that experts express the opinions indistinctly more adequately. However experts thus effectively work in simple situations, in particular at a scalar sign of condition HF, and in a problem considered by us a sign of condition HF the vector. At the same time under production conditions the loop is exposed to numerous revolting influences, both from bushes of chinks, and from an environment, including from installation of preparation of gas. Hence, the measured values x have casual character. In that case it is expedient to present x as a random variable and for its description to use multiple-valued characteristic function-function of distribution.

It is necessary to notice, that in the presence of a static material for the purpose of diagnosing HF use of static methods has a clear advantage before others and including before methods of the theory of indistinct sets as distribution function constructed on a static material reflects a reality more adequately, rather than subjectively defined functions of an accessory.

The problem of the first stage of classification of conditions HF is represented as a three-alternative optimising problem to a vector sign. As criterion of optimisation the generalised average risk of a kind is used

$$R = \sum_{j=1}^{M} \sum_{j^1=1}^{M} \int_{xj^1} \omega_{jj^1}(x,a) P_j p_j(x) dx, M = 3, \tag{1}$$

Where $\omega_{jj^1}(\cdot)$ function of losses (penalty) for wrong reference of observable value x, belonging to subset X_j to subset $X_{j^1}; \omega_{jj}(\cdot)$ encouragement function for correct recognition x as element x_j, i.e. reference x, belonging X_j to the same subset. And $\omega_{jj'}(\cdot) \geq 0$ for $j \neq j; \omega_{jj}(\cdot) \leq 0$ which are defined to accuracy of a vector of parametres a, structures $\omega_{jj'}(x,a), j, j' = \overline{1,m}$ with unknown parametres are set: P_j - aprioristic probability x in $X_j; p_j(x)$ distribution density x in X_j.

As it is possible to notice, in the presented kind of average risk, unlike traditional losses instead of constant factors it is used functions of losses.

Dividing functions of subsets X_1, Xx_2, X_3 by criterion (1) are defined from a necessary condition of its minimum on a vector of parametres $a = (a_1 .....a_n)$ For this purpose in the beginning on the available statistics is defined $P_j, p_j(x)$. At a priori known law of distribution for construction p (it is enough to define estimations of its parametres. For example, for the normal law of distribution which takes place in our problem, such parametres are average value and a dispersion.

Dividing functions generally it is defined for each pair of the next subsets of conditions HF. Considering, that, in a considered problem next are accordingly X_1, X_2 and X_2, X_3 dividing functions are defined for these pairs subsets, $f_{12}(x,a)$, $f_{23}(x,a)$. This purpose into criterion (1) enters two-place characteristic functions of subsets $X_j, j = 1, M$.

$$\theta_j(x,a)=\begin{cases}1, & \text{if } x\in X_j\\ 0, & \text{if } x\notin X_j\end{cases} \tag{2}$$

Thus (1) takes a form:

$$R=\sum_{j=1}^{M}\sum_{j=1}^{M}\int_X \theta_j(x,a)\cdot\omega_{jj}(x,a)P_j p_j(x)dx \tag{3}$$

From a necessary condition of a minimum (3): $\frac{\partial R}{\partial A}=0$ it agree

$[1.2]$ Two systems of the equations turn out:

$$\sum_{j=1}^{M}\sum_{j^1=1}^{M}\int_X \theta_j(x,a)\nabla_a\omega_{jj1}(x,a)P_j p_j(x)dx=0$$
$$, \tag{4}$$
$$\sum_{j=1}^{M}\sum_{j^1=1}^{M}\int_X \Delta_a\theta_j(x,a)\omega_{jj1}(x,a)P_j p_j(x)dx=0$$
.

From the decision of the first system of the equations will be defined a vector of parametres *and*, and at a known vector *and* from the second system dividing functions $f_{12}(x_1a), f_{23}(x,a)$ are defined.

Considering, that $\nabla_a\theta_j(x,a)$ multidimensional δ - function which everywhere except borders of section $X_j, x_{j'}$, $j'=1,m$ has zero value, from the second parity (4) we receive expressions of dividing functions:

$$F_{12}(x,a)=\left[w_1(x,a)-\omega_{12}(x,a)\right]P_1p_1(x)+\left[\omega_{21}(x,a)-\omega_{22}(x,a)\right]P_2p_2^{(x)}=0$$
$$f_{23}^{(x,a)}=\left[\omega_{22}(x,a)-\omega_{23}(x,a)\ \right]P_2p_2(x)+\left[\omega_{32}(x,c)-\omega_{33}(x,a)\right]P_3P_3^{(x)}=0 \tag{5}$$

Considering, that $x=(x_1x_2)$ expressions $f_{12}^{(\bullet)}, f_{23}^{(\bullet)}$ can be written down on elements x_1, x_2. Thus, for example, f_{12} the form is taken:

$$f_{12}(x,a)=\left[\omega_{11}(x_1,x_2,a)-\omega_{12}(x_1x_2,a)\right]P_1p_1(x_1,x_2)+\left[\omega_2(x_1,x_2,a)-\omega_{22}(x_1,x_2,a)\right]P_2p_2(x_1,x_2)=0$$

On the basis of constructed $f_{12}(x,a)t_{23}(x,a)$ the rule of reference of current values to a concrete subset, i.e. recognition x is defined:

$$x^{(S)}\in X_1,\ \text{if } f_{12}(x^{(S)},a)<0;$$
$$x^{(S)}\in X_2,\ \text{if } f_{12}(x^{(S)},a)>0, f_{23}(x^{(S)},a)<0; \tag{6}$$
$$x^{(S)}\in X_3,\ \text{if } f_{23}(x^{(S)},a)>0$$

At $f_{12}(x^{(S)},a)=0, f_{23}(x^{(S)},a)=0$ the decision is not accepted, where S is number of current value x.

As is known the decisions accepted about borders have small reliability from - for values *p ()*. Therefore it is expedient to enter a zone of unauthenticity of the accepted decisions *h*, in that case corresponding decisions in (6) are accepted at $f_{12}(x^{(S)},a)<h; f_{12}(x^{(S)},a)>h, f_{23}(x^{(S)},a)<h \quad f_{23}(x^{(S)},a)>h$, are not accepted, when $\left|f_{12}(x^{(S)},a\right|<h, \left|f_{23}(x^{(S)},a\right|\le h$.

By a rule (6), having defined sets to which belongs $x^{(S)}$ display of the last to this set its concrete coordinates are defined. Linear $f_{12,}f_{23}$, constructed on a certain fragment of a statistical material it is presented on a plane x_1, x_2 (see fig.).

In drawing for ten consecutive supervision $x^{(s)}, s=N,10$.

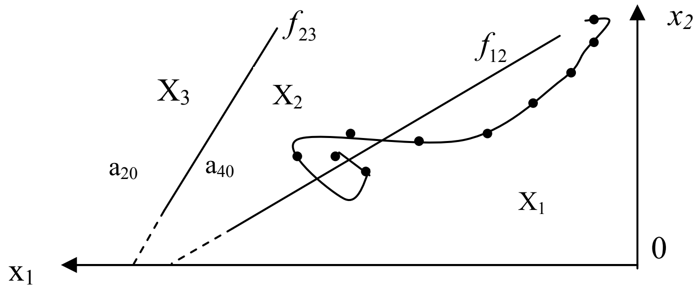

Fig. Drawing $f_{12}(x^{(S)}, a)$, $f_{23}(x^{(S)}, a)$

From drawing it is possible to notice, that $x^{(S)}$ passing from set X_1 in X_2 through f_{12} it is a little leaving from border back comes back in x_1. This results from the fact that at transition $x^{(5)}$ from x_1 in x_2 works an expense regulator in a loop.

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