1.8.7. VIBRODIAGNOSTIC AND REAL-TIME CONDITION MONITORING OF DANGEROUS PLANTS EQUIPMENT

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Monitoring of unit's technical state – the observation of its operability change with the purpose of personnel warning about the limiting state obtaining – allows to transfer the majority of failures from the category "sudden" to the category "gradual" due to their early detection and timely warning of personnel. Real-time monitoring has a number of significant differences from on line/off line monitoring the meaning of which is a strict regulation of monitoring interval на уровне 10 – 20% interval of the most quick development of production complexes (PC) equipment failures. It's possible based on automatic systems with functionally undefined structure which doesn't depend on equipment construction for the wide range of PC's units and includes multilevel expert system. These are allows to implement diagnostic and monitoring systems (DMS) in conditions of prior uncertainty when types of bearings, number of impeller's blades, etc. are unknown, and to minimize static, dynamic mistakes and risk of the equipment failure passing. The principle of information completeness (π-principle) during the choice of state diagnostic features in conditions of prior uncertainty is formulated. According to this principle features should arrange a complete group in statistical sense including both all known features and supplemented features in the selected base of signals. This allows to decrease significantly a probability of defects passing, diagnostic features of which in this base are unknown. The most common and broadband signals' base is vibration that's why obtained conclusions will be correct for other signals' bases (current, temperature, etc). The primary goal of diagnostic and monitoring systems is synthesis of orthogonal diagnostic features $\{Y_i\}$, correspondingly representing formulated orthogonal classes of failures $\{S_i\}$. It corresponds to reduction of observation matrix $\mathbf{[C]}$ to diagonal square matrix defining one-one (regressive) relation between diagnostic feature and corresponding generalized error. So, the problem of condition monitoring consists in formation of correct interpretation of this generalized error taking into account rate of failures classes' appearance. Danger of unit's and whole production complex's state is defined by maximal partial component of vibroparameters trend's growth rate $\dot{Y}_{\max}(t)$ which is observed by DMS among all rates of units' components and whole petrochemical complex accordingly. Necessary operating speed of DMS is determined by maximum speed of operability loss and minimum reserve of diagnosed unit limiting state:

$$F = \frac{1}{T} = \max\left(B\frac{\dot{S}_{NDP}}{S_{NDP}} \right) = \max\left(B\frac{\dot{Y}_{NDP}}{Y_{NDP}} \right).$$

Parameter B characterizes the quality of estimation algorithm of measured diagnostic features growth rate. The offered models and definitions are the base of diagnostic means and DMS with functionally undefined structure, the novelty of which is confirmed by patents for invention.

Real-time continuous measurement of the new independent diagnostic feature – growth rate of the trend – almost in two times increased interval of time during which personnel of petrochemical complex can prevent failure, manufacturing defect and restore a safe state of object without violation of technological process normal functioning. Max-

Maximum interval of prediction exceeds almost in 10 times interval of observation with prediction mistakes less than 15%. Such comprehensiveness of prediction became possible due to the effective mathematical model. Practical realization of mentioned theoretical approaches in complex monitoring systems COMPACS® which use different methods of diagnostics – viabroacoustic, acoustic-emissive, thermal, electric, etc., provided their wide implementation. More than 400 systems were implemented for the last 15 years almost in open air at the enterprises of such large companies as OJSC "Gazprom", OJSC "Lukoil", OJSC "Rosneft", OJSC "TNK-British Petroleum", etc. and also abroad; on domestic and import equipment of more than 1000 types; in different geographical and climatic zones.

Table 1. Comparison of Characteristics of Real-time, on Line and off Line Monitoring

<table>
<tr><th colspan="4">MONITORING</th></tr>
<tr><th>Function</th><th>ON LINE</th><th>REAL TIME</th><th>OFF LINE</th></tr>
<tr><td>1. Preparation of object and equipment</td><td rowspan="2">Measurement with minimum interval</td><td rowspan="5">Execution of all procedures 1 – 7 with regulated general interval which is not exceeds 10 – 20% of the shortest interval of failures development.

Necessity of automation of all procedures 1 – 7 for providing of minimum static – s, dynamic – d errors and risk of equipment failure passing – $r = s + d$</td><td rowspan="2">Execution of procedures 1 – 4 as required. Interval of time is not regulated.
Procedures 1 – 4 is poorly observable!</td></tr>
<tr><td>2. Measurement of informative parameters and alarming</td></tr>
<tr><td>3. Formulation and documentation of diagnosis</td><td rowspan="5">Interval of time for procedures 3 – 7 is not regulated. Procedures 3 – 7 are not observable!</td></tr>
<tr><td>4. Preparation of diagnostic directions</td></tr>
<tr><td>5. Delivery of directions to personnel for corrective actions</td><td rowspan="3">Interval of time for procedures 5 – 7 is not regulated.
Procedures 5 – 7 poorly observable!</td></tr>
<tr><td>6. Performing of corrective actions for restoration of object's operability</td></tr>
<tr><td>7. Management control of personnel actions and their correction in case of need</td></tr>
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Conclusions:

1) The determinated partial functions of unit's ageing and their rates defined by generalized errors, structural parameters and rates of their growth, are offered for use as variables of unit's state;

2) Technical state of production complex and correspondingly the risk of its operability loss are offered to evaluate in accordance with minimum residual operability and maximum rate of its loss, observed by diagnostic and monitoring systems among the

group of units composing the complex;

3) The necessary operating speed of diagnostic and monitoring system is offered to estimate according to the observability criteria of maximum speed of residual operability loss in petrochemical complex;

4) Real-time monitoring allows to transfer failures of equipment and production complexes from the category "sudden" to the category "gradual";

5) The necessity of failures reduction by dozens of times and corresponding increase of equipment run-to-failure requires decrease of monitoring mistakes up to minimum % and less (zero-monitoring);

6) Decrease of static error and reduction of terms for Real-time monitoring systems implementation up to several months requires development of etalonless diagnostic methods and standard techniques of invariant to equipment type diagnostic features formation;

7) Decrease of dynamic error requires significant excess of monitoring rate, i.e. not only measurements but also diagnosis and its realization, over rates of failure development in production complexes;

8) It requires automation of all monitoring techniques from measurement of parameters and automation of diagnostic output of information about equipment state up to its unhampered and timely delivery and presentation in all levels of production complex management.

References:

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