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CONCEPT AND CLASSIFICATION OF COMPLEX DIAGNOSTICS

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Abstract. This article discusses the theoretical foundations of complex diagnostics and its role in assessing the technical condition of complex systems. The main principles of complex diagnostics, multiparameter evaluation methods, and mathematical models used for system state identification are analyzed. A block diagram of the diagnostic process is developed, and its operational algorithm is described. The results demonstrate that an integrated diagnostic approach significantly improves the reliability and efficiency of technical systems.

Keywords: complex diagnostics, technical condition, monitoring, mathematical model, system analysis, diagnostic parameters.

Аннотация. В данной статье рассмотрены теоретические основы понятия комплексной диагностики, а также её роль в оценке технического состояния сложных систем. Проанализированы основные принципы комплексной диагностики, методы многопараметрической оценки и математические модели, применяемые для определения состояния системы. Представлена блок-схема диагностического процесса и описан алгоритм её функционирования. Результаты исследования показывают, что комплексный подход значительно повышает надёжность технических систем.

Ключевые слова: комплексная диагностика, техническое состояние, мониторинг, математическая модель, системный анализ, диагностические параметры.

Annotatsiya. Mazkur maqolada kompleks diagnostika tushunchasining nazariy asoslari, uning texnik tizimlarni baholashdagi o‘rni va ahamiyati keng yoritilgan. Kompleks diagnostikaning asosiy tamoyillari, ko‘p parametrli baholash usullari hamda matematik modellar asosida tizim holatini aniqlash mexanizmlari tahlil qilingan. Shuningdek, diagnostika jarayonining blok-sxemasi ishlab chiqilib, uning ishlash algoritmi tavsiflangan. Tadqiqot natijalari murakkab texnik tizimlarning ishonchliligini oshirishda kompleks yondashuv muhim rol o‘ynashini ko‘rsatadi.

Kalit so‘zlar: kompleks diagnostika, texnik holat, monitoring, matematik model, tizimli tahlil, diagnostik parametr.

Modern technical systems, in particular, fuel and lubrication systems of aircraft, have a high level of complexity. Their reliable operation depends on many factors, and it is difficult to fully assess them by monitoring individual parameters.

Therefore, it is necessary to organize the diagnostic process based on an integrated approach.

Comprehensive diagnostics allows you to determine the real technical condition of the system by analyzing all the main parameters of it together.

Comprehensive diagnostics is the process of integrating various physical, mathematical and information methods to determine the technical condition of an object. It includes the following main elements:

-a set of diagnostic parameters;

-mathematical and algorithmic models;

-decision-making system;

-monitoring and control tools.

Mathematical model of the diagnostic process

Complex diagnostics is represented by the following general functional relationship:

D(t)=f(X(t),U(t),Z(t))

Where: D(t) is the diagnostic state of the system, X(t) is the vector of measured parameters, U(t) is the external influences, Z(t) is the internal latent parameters.

Integral evaluation model

Multi-parameter diagnostics is determined by the following sum:

$$K = \sum_{i=1}^{n} w_i \cdot \frac{x_i - x_i^{norm}}{x_i^{max} - x_i^{min}}$$

Where: K is the general diagnostic indicator, ш i is the weighting coefficient,
xi is the measured parameter, xi · is the normal value.

Failure probability model

A probability model is used to assess reliability in diagnostics:

Pf=1−e−λt

Here: Pf — failure probability, λ — failure intensity, t — time.

Classification of complex diagnostics

Complex diagnostics are classified based on the following main characteristics.

By the level of coverage:

- Element-level diagnostics;
- System-level diagnostics;
- Complex (integrated) diagnostics.

By implementation time:

- On-line (in real-time mode);
- Off-line (based on scheduled checks).

According to the methods used:

Analytical (based on mathematical models);
Experimental (based on experimental results);
Intellectual (artificial intelligence, neural networks).

According to the nature of information:

Deterministic;
Stochastic;
Fuzzy (based on fuzzy logic).

Block diagram of a complex diagnostic system. Below is the sequence of operations of a complex diagnostic system:

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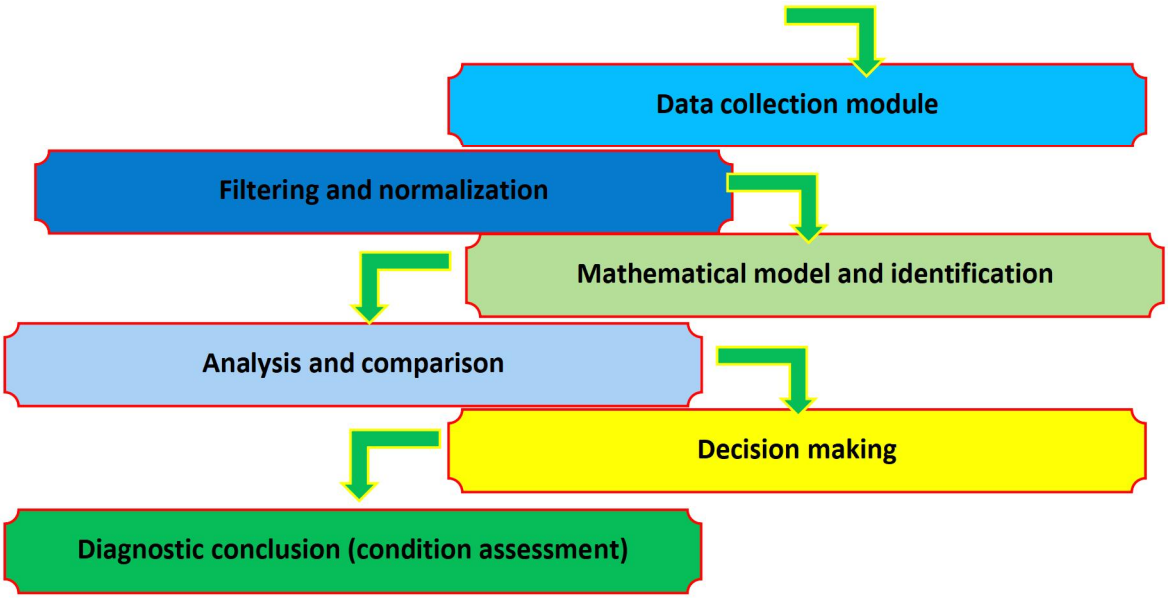


Figure 1. Block diagram of a complex diagnostic system

Advantages of complex diagnostics:
-Multi-parameter assessment capability;
-High accuracy and reliability;
-Early detection of faults;
-Possibility of automation;
-Possibility of predictive maintenance.

Proposals and recommendations

Proposal for the integration of a complex diagnostic system. In order to effectively organize the diagnostic process in technical systems (especially fuel and lubrication systems), it is necessary to combine all control parameters into a single information system.

Proposal:
-Creating an integrated platform that collects and processes data from sensors in real time;
-Using various diagnostic methods (analytical, experimental, intellectual) in a single system.

Improving the multi-parameter evaluation model In current diagnostic systems, parameters are often evaluated separately, which reduces accuracy.

Proposal:

Applying the following generalized model that takes into account the relationship between parameters:

$$K = \sum_{i=1}^{n} w_i x_i + \sum_{i \neq j} k_{ij} x_i x_j$$

Here: kij — interaction coefficient between parameters.

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This approach allows for a more accurate assessment of the system state. The introduction of artificial intelligence-based diagnostics may not be effective enough in complex systems where traditional methods are not effective enough. Proposal:

-Introduction of neural networks and machine learning algorithms;

-Development of a predictive diagnostic model for early detection of malfunctions.

It is important to automate the diagnostic process to reduce the influence of the human factor and increase speed. Proposal:

-Full automation of the diagnostic process;

-Inclusion of expert system elements in the decision-making unit.

To increase diagnostic accuracy, use filtration methods, since there may be noise and errors in the measurements. Proposal:

-Use modern filtration methods such as Kalman filter, adaptive filters;

-Reduce the likelihood of incorrect decisions by cleaning the signal.

The results of the diagnostic implementation of a reliability assessment system should indicate not only the state, but also the probability of future operation of the system.

Proposal:

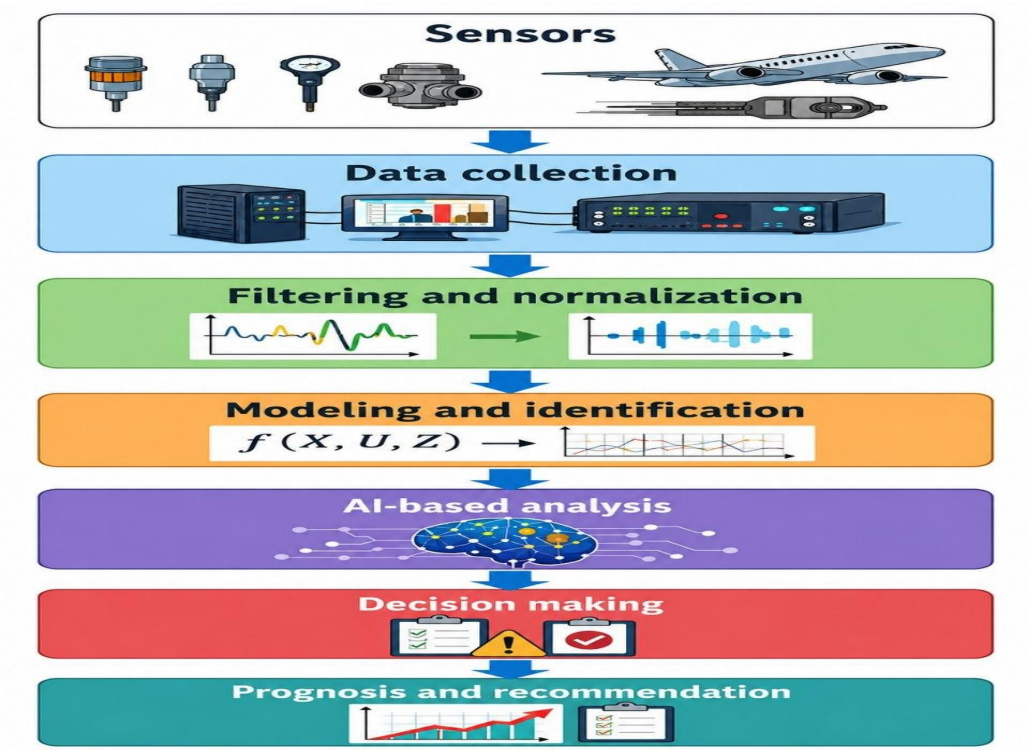
Using a model for assessing the probability of failure:

$$Pf=1-e-\lambda t$$

Developing algorithms for determining the remaining resource Improving the block diagram of a complex diagnostic system In current systems, there are often interruptions between stages.

Proposal:

Working on the basis of the following optimized structure:



[Sensors]↓
[Data Collection]
↓
[Filtering and Normalization]
↓
[Modeling and Identification]
↓
[AI-Based Analysis]
↓
[Decision Making]
↓
[Prediction and Recommendation]

It is necessary to expand experimental tests and practical confirmation of theoretical models. Proposal:

Increase accuracy by conducting tests close to real conditions through experimental stands, comparing model and real results.

General conclusion (on proposals)

The implementation of the above proposals in practice will significantly increase the efficiency of the complex diagnostic system. In particular, by using multi-parameter analysis, artificial intelligence and automation elements, the reliability, safety and operational efficiency of technical systems will be increased to a high level.

Conclusion

Complex diagnostics is an important tool for the effective management of modern technical systems and ensuring their reliability. It provides more accurate and reliable results by combining various diagnostic methods into a single system. The use of complex diagnostics, especially in complex systems, is of great importance in preventing technical failures and increasing operational efficiency.

References

1.Isermann R. Fault-Diagnosis Systems: An Introduction from Fault Detection to Fault Tolerance. Springer, 2006.
2. Venkatasubramanian V. Process Fault Detection and Diagnosis. Elsevier, 2013.
3. Patton R., Frank P., Clark R. Issues of Fault Diagnosis for Dynamic Systems. Springer, 2000.
4. Blanke M. va boshqalar. Diagnosis and Fault-Tolerant Control. Springer, 2016.
5. Himmelblau D. Fault Detection and Diagnosis in Chemical and Petrochemical Processes. Elsevier, 1978.
6. Ljung L. System Identification: Theory for the User. Prentice Hall, 1999.
7. O‘zbekiston Respublikasi ilmiy-texnik jurnallari materiallari, 2020–2024.