Technology of diagnostics of devices and subsystems of autonomous power systems

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Relevance of the issue

There are a significant number of areas that do not have access to centralised power supply for various reasons (occupied territories, mountainous regions, field military units, remote villages, etc.) It is worth highlighting infrastructure facilities that, in the absence of centralised power supply, must be connected to autonomous power systems almost instantly and reliably. These are primarily hospitals with patients on life support and artificial lung ventilation, as well as military field hospitals. Decentralised power supply systems are supplied with electricity, as a rule, through the use of diesel generator power plants.

At the same time, more and more attention is being paid to improving the reliability of such power plants due to the criticality of the facilities that are powered by them. The issue of improving the reliability and quality of operation of these power plants depends on the condition of the equipment, fuel quality, operating conditions, the nature of the load and a number of other factors.

To ensure the reliable operation of autonomous power systems, it is important to constantly diagnose the technical condition and monitor the operating parameters during technical operation.

Therefore, the research topic of improving the reliability of diesel engines in autonomous power systems is relevant.Please note that the first paragraph of a section or subsection is not indented. The first paragraphs that follows a table, figure, equation etc. does not have an indent, either.

Methodology for synthesis of diagnostic graph model

The technical condition of a diesel engine as a mechanical system is largely determined by parameters that characterise the state of the mating rubbing pairs: fuel equipment, cylinder-piston group, diesel engine crankshaft bearings, and valve train. These parameters do not affect the functional parameters of the diesel engine up to a certain limit - they are passive. However, they ultimately determine the service life of the diesel engine up to the relevant limit states and cause failures. The general situation for determining a set of parameters for monitoring the performance and diagnosing a diesel engine of a power plant and functionally related systems can be represented as follows. The diesel engine of a power plant and functionally related systems have a set of functional elements L (the diesel engine itself, heat exchangers, pumps, etc.). They are characterised by sets of internal parameters M consisting of subsets E, F, R and a set of defects D. Let's introduce an additional subset O of the internal parameters of the object, which we will call determining, sensitive to the appearance of a particular defect or malfunction

$$\left(O=\left\{o_1,\ o_2,...,o_g\right\},\ O\subset M\right). \qquad (1)$$

To determine the operability of the object and recognise defects, the use of all elements of the set O seems impracticable and unnecessary, since it entails obtaining redundant information. In addition, as noted above, not all parameters of these sets are equally accessible and measurable. It follows that it is necessary to identify some sets of control parameters B, such that $B\subset O$.

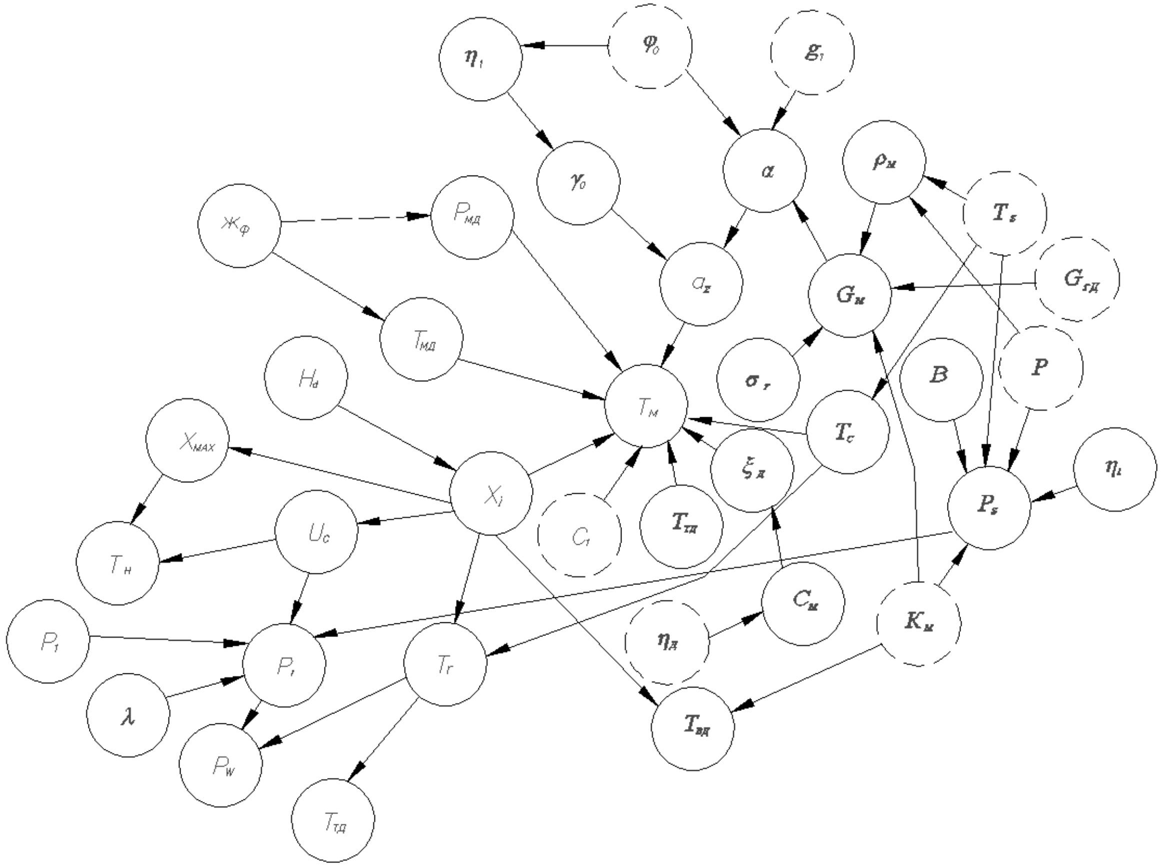
Table 1. Scale of parameter estimates by the indicator of measurement availability.

Characterisation of the situation	Absolute assessment of parameter availability	Relative assessment of parameter availability
1. The parameter can be determined using a standard instrument already installed in the power plant.	5	1
2. The parameter can be measured without modifying the design of power plants and functionally related systems using devices similar to standard ones.	4	0,8
3. The parameter can be measured with minor modifications to power plants and functionally related systems or with the use of sufficiently compact, easy-to-use special measuring equipment.	3	0,6
4. To measure the parameter, it is necessary to carry out a more substantial modification of the diesel generator set, to use special, not fully compact and difficult to use control equipment, minor dismantling and installation work.	2	0,4
5. The parameter can be measured in principle, but it requires significant dismantling and installation work, complex in all respects of measuring devices, if any, but it can be carried out in the course of routine maintenance.	1	0,2
6. With the existing measuring instruments available at the moment (or at all), the parameter cannot be measured, or it requires removal of the unit or assembly from the autonomous electrical system of the military facility.	0	0

Diagnostic graph model for the workflow of a vehicle diesel engine

The graph model of the diesel engine workflow based on a substantive description and functional dependencies is shown in Fig. 1.

In Fig. 1 Ra - pressure at the beginning of compression; Ta - temperature at the beginning of compression; Gvz - amount of air supplied to the diesel engine; Tvd - temperature of water at the inlet to the diesel engine; n1 - compression polytropy index; ε - compression ratio; nd - diesel crankshaft rotation frequency; cmi - piston speed; ξv - vortex creation coefficient; gf - injector control; Pf injection - fuel injection pressure; Tf injection - fuel temperature; τ injection - injection duration; Pc - pressure at the end of compression; Tc - temperature at the end of compression; Ct - cetane number of fuel; τdelay - ignition delay period; Gvz - amount of fresh charge; σr - hydraulic coefficient; ρvz - air density; α - excess air coefficient; ηn - filling coefficient; φk - valve opening angle; γo - residual gas coefficient; qtc - cycle fuel supply; αΣ - total excess air coefficient; xi - heat release intensity; xmax - active heat release coefficient; Nu is the calorific value of fuel; Tz is the maximum combustion temperature; Pz is the maximum combustion pressure; Pg is the pressure force of gases in the cylinder; υcg is the combustion rate; τcg is the combustion duration; Tvg is the temperature of exhaust gases; Pvg is the pressure of exhaust gases; Tx is the temperature of the walls of the combustion chamber; λ is the degree of gas pressure in the cylinder.


η_1
φ_0
g_1
γ_0
α
$\rho_м$
$T_в$
$Ж_ф$
$P_{МД}$
a_z
$G_м$
$G_{гД}$
$T_{МД}$
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B
P
H_d
$T_м$
T_c
X_{MAX}
X_i
$\xi_л$
η_i
$P_в$
U_c
C_1
$T_{тл}$
$T_н$
P_1
$P_т$
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$C_м$
$\eta_л$
$K_м$
λ
P_W
$T_{вд}$
$T_{тд}$

Conclusions.

1. The proposed methodology for synthesising a diagnostic graph model of a diesel engine of an autonomous power plant, based on the use of the graph theory method, allows, with relative ease of use, to obtain results that correspond to the actual state of operation of a diesel engine of a power plant. This is achieved through the use of specially selected groups of diesel engine output control parameters as diagnostic parameters of the graph model. These indicators are available for measurement without significant dismantling and installation work, the use of complex measuring instruments, but they can be measured during routine maintenance and operation.

2. A methodology for selecting the initial parameters of a diagnostic graph model of a diesel engine is proposed, which includes the process of forming the minimum required sample of diesel engine functioning parameters. The following parameters have been selected as parameters for assessing the technical condition of diesel engines of power plants and functionally related systems and circuits:

- power of power plants;
- diesel crankshaft rotation frequency;
- fuel consumption;
- a group of thermal engineering parameters.

This minimum required set of system state parameters allows us to link the diagnostic scheme for the studied technical condition of power plant diesel engines and their performance indicators.