A method of estimating the actual state of electromechanical systems based on the use of a model, connected in parallel with the diagnosed equipment, and an indirect measurement of the state variables is considered. A diagnostic system structure is proposed and also versions of models which take the operating features into account.

Key words: electromechanical system, state space, parallel models, diagnostics.

An estimate of the technical state of electromechanical systems can be based on diagnostics, carried out in real time, using specialized computer systems. Among the large number of methods, we can distinguish diagnostics based on an analysis of the state variables, which enables not only the operability to be determined, but also enables faults in specific devices of the system undergoing diagnostics to be established. However, it is difficult to carry out such a diagnostic procedure since in practical electromechanical systems some of the state variables will be inaccessible for direct measurement and use.

In fact, if we consider the system shown in Fig. 1, it consists of a mechanical system, a drive mechanism and a computer diagnostic unit. In the drive mechanism, the measurable variables are related to the regulation of the current and speed, which are used to obtain the control laws, and hence can be measured. However, this is insufficient to determine the technical state of the system. The problem then arises of constructing a model which enables the output variables $y$ to be measured and enables quantities the values of which are equal to the state variables of the actual drive mechanism to be reconstructed.

It would be possible to construct such a model, which exactly generates the variables $x$, if it was delayless. In the majority of cases, in view of the specific features of the construction of diagnostic systems, the measuring circuit together with the unit for processing the data has a time lag, and hence one obtains a model which, instead of generating $x$ generates an estimate $\hat{x}$.

If the number of output variables accessible for measurement is equal to the number of state variables $n$, this particular problem does not arise and the algorithm will operate with the system of algebraic equations

$$y_i = c_1 x_1 + c_2 x_2 + \ldots + c_n x_n, \quad i = 1, 2, \ldots, n.$$ 

On the one hand, the number of variables accessible for measurement is less than the number of required state variables, while on the other, to carry out diagnostics it is desirable to have the minimum number of quantities to be measured. In such cases it is necessary to have access to additional information, for example, to use the values of $y(t_k)$ at preceding instants of time $t_k < t$, differentiated with respect to time. The measuring system must then have a memory device, i.e., the model should be basically dynamic but with a lag. This is achieved by using microprocessors in the structure of the diagnostic system. In cases when the initial system is linear and steady, the model can also be constructed analogously.
The diagnostic procedure considered involves constructing a model which operates in parallel with the main process. Naturally, such a model should adequately reflect the processes occurring in the actual device. This must essentially be some estimator of the state variable from the results of a measurement of the output variables \( y \), reminiscent in its structure to a device for estimating the useful signal on a background of noise, usually called Luenberger filters. But unlike Wiener, Kalman–Bucy and similar filters, Luenberger filters are constructed to separate and estimate deterministic and not stochastic signals. The latter enables us to use simpler models of the devices considered.

In the overwhelming majority of electromechanical systems, there is a single input (a controlling action) and one output (most often of all this is the speed of the operating device). The electromechanical system can then be regarded as a system with a single input \( u \) and a single output \( y \) [1, 2]:

\[
\begin{aligned}
\dot{x} &= Ax + bu; \\
y &= cx,
\end{aligned}
\]  

where \( x \in \mathbb{R}^n \), \( A \) is a constant \( n \times n \)-matrix, \( b \) and \( c \) are \( 1 \times n \)-vectors, and \( u \) and \( y \) are scalar variables.

The problem is as follows: knowing the matrices \( A, b, \) and \( c \) and having at any instant of time information on the variables \( u \) and \( y \), it is required to obtain an algorithm for calculating \( x \) and a model which performs the algorithm obtained.