Synthesis and analysis of intellectual models for diagnostics the technical state of a turbine unit

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Abstract

Research results: there are synthesized and investigated intellectual models of diagnostics of turbine units; developed software that implements diagnostic models in industrial controllers; tested algorithms (models) for diagnostics the state of turbine units under industrial conditions of an operating power station; the expected economic effect is the extension of the between-repair period of turbine-units by 15-20%.

Keywords: technological object, technological state, turbine unit, fuzzy algorithms, neural network algorithms, neuro fuzzy algorithms, diagnostic algorithms, operative diagnostics system

1 Introduction

At the first stage of the development of industrial production the maintenance of operational reliability or serviceability of technological equipment (hereinafter - TE) was carried out "to failure." In the second half of the last century there was appeared and successfully applied until present another direction - scheduled preventive maintenance. However, in market conditions it becomes obvious - it is necessary to move on to a more progressive strategy of ensuring the operational reliability of the TE - "according to its actual state". The transition to this strategy needs the creation of a system for the operational diagnostics of the technical state of the TE. The application of the TE systems according its actual state makes it possible to increase production efficiency by reducing the time of equipment downtime in repair, reducing the cost of production by reducing the cost of repairs and the emergency repair of the equipment.

The cost on the creation of an automated system of operational diagnostics will be significantly reduced if it will be included in the structure of the current automated control system of technological process (ACSTP) as its subsystem. In this case, there will be used the information support of the operating ACSTP, which significantly reduces the costs of its development and implementation. At the same time, the effect from the implementation of an extended ACSTP will increase significantly, because in addition to effects from operational and optimal process control there will also be achieved the effect from operational diagnostics of the TE. In addition, it is possible to expect the appearance of a so-called *synergistic* effect - when the effects from the ACSTP and the operational diagnostics subsystem are much higher than their simple sum. This occurs as a result of the interaction of process control and the diagnostics of the TE: on the one hand, the operative and optimal management of the process favorably affects the TE, and on the other hand, operational diagnostics allows to maintain the TE state at the proper level, thereby improving its manageability. Diagnostic functions allow the subsystem at an early stage to fix the beginning of destructive processes in the TE and to localize them in time.

2 Research methods

As a result of the conducted researches, we synthesized four models for diagnostics the technical state of a turbine unit using the following methods: fuzzy algorithms, neural network algorithms, neural networks, and the method of experiment plugging. Comparative table 1 of these models showed that the best result was shown by neuro fuzzy networks 0.8% of error, that is a very good result compared to traditional methods (the method of experiment planning showed 6.75% of error).

TABLE 1 Comparative table

Modeling method	**The value of absolute error % *Y***
1. fuzzy algorithms	1,15101 %
2. neural network algorithms	1,146136 %
3. neuro fuzzy networks	0,88102 %
4. experiment planning	6,75%

Therefore, further researches on model sensitivity, uniqueness and stability were carried out only for the neuro fuzzy model.

The results of modeling the assessment of the technical state of one of the elements of the turbine unit - high-pressure cylinder (HPC) - showed that they are justified from the point of view of the technological process physics of the turbine unit and fully reflects the experts' estimates.

3 Conclusion

As a result of the conducted researches, we adopted the following recommendations for the elimination of

emergency situations at the HPC:

a. if the value Y lies in the range from 0 to 0.25 - the HPC is in the normal state;
b. if the value Y lies in the range from 0.26 to 0.5 - an emergency situation is possible, the more careful control and the necessary preventive actions of the operational personnel given above are required;
c. if the value Y lies in the range from 0.51 to 0.79 - a pre-emergency situation;
d. if the value Y lies in the range from 0.8 to 1.0 - an emergency situation has arisen.

Depending on the assessment of the HPC technical condition the operational diagnostic subsystem can take one of the following solutions:

- in case (a) – to do nothing;
- in case (b) – to analyze the possible causes of the HPC technical condition deterioration: to check the temperature of the bearings at a place and the temperature of cooling water; to check lubricant circulation and oil pump operation; to check the pressure in the discharge chamber of the HPC and in front of it; to check the operation of the heating lines for flanges and studs; to check the position of the shaft of the turbine by special marks;
- in case (c) - depending on the results of the analysis to perform one of the following actions: to identify the cause of the bearings temperature rise, and to eliminate it according to the instructions and the above mentioned measures; if necessary, to reduce the steam flow to the top of the turbine in order to normalize the pressure in the discharge chamber of the HPC; if necessary, to adjust the work of heating lines for flanges and studs;
- in case (d) – to act according to the order of the workshop technician, the shift supervisor or the deputy chief of the operation department or the person replacing him.

Similarly, it is possible to generate a planning matrix of the FFE and for assessing the technical state of other elements of the turbine unit: LPC, PS, generator. The problems of this class are fixed by the corresponding sensors, and the reaction on them is specified in the technological instructions and can be duplicated on the monitor screen with the help of the operational diagnostics subsystem.

Therefore, the proposed method for assessing the technical state of the turbine unit allows early to predict the occurrence of emergency situations.

The developed algorithms for diagnostics the technical state of the turbine unit were tested at Almaty CHP-2. The expected economic effect is the extension of the between-repair period of turbine units by 15-20%.