ABOUT WAYS TO INCREASE RELIABILITY AND ECONOMY OF STEAM BOILER INSTALLATIONS OF BLOCK POWER PLANTS

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Abstract

The new method and algorithm of management by reliability and profitability of work of steam boiler installations block power stations is developed. The essence of a method is reduced to definition of "weak parts» and to formation of recommendations. In a basis of a database and program model, there are results of measurement and calculation of technical and economic parameters steam boiler installations. And the method allows to formulate the main directions of increasing the efficiency of individual control steam boiler installations and steam boiler installations of power plants as a whole. Improving the efficiency management system of the steam boiler installations allows, first of all, to reduce operating costs. The developed method allows us to consider the obtained results as methodological support for personnel in organizing the operation, maintenance and repair of steam boiler installation. Therefore, the relevance of this problem is obvious

Keywords: Reliability, profitability, ranking, power stations, management, steam boiler, installation

I. Introduction

The recommended method and calculation program are implemented as a subsystem of the automated system for analyzing the technical condition of power units [1].

Along with the existing intuitive ranking system of power plant steam boiler installations (SBI), the calculation results of this system should be used as methodological support for personnel [2].

This article addresses the following issues:

1. Evaluation of the results of the traditional approach to improving the efficiency of power plant SBI
2. Development of methods and algorithms allowing:
   - obtain a quantitative assessment of the technical condition of the SBI, identify the main areas for improving the efficiency of its operation
   - evaluate the results of operational management of the efficiency of the SBI based on information on quantitative assessments of technical and economic indicators calculated for a given estimated time period $\Delta\tau$
   - assess the maintainability of the technical condition of the SBI during downtimes not associated with the restoration of wear of the SBI components
   - to formulate a strategy for scheduled repairs SBI and to assess the quality of repairs.

II. Methods

Table 1 shows quantitative estimates of average technical and economic indicators of gas-oil fueled SBI, and Table 2 shows the indicators of individual SBI power units for some three consecutive months of the year. These data will be used to illustrate the solution of each of the above problems

Table 1: Estimates of average values of technical and economic indicators of the power plant steam boiler installations

N	Indicators			Months of year		
	Name	Conventionl designation	Unit of measurement	A	B	C
1	Specific load	h_{ave}	10^4 t/h. MVt	34,75	34,58	34,38
2	Air temperature after regenerative air heater (RAH)	T_{air}	^0C	295,9	293,6	290,4
3	Exhaust gas temperature	T_{eg}	^0C	132,1	131,9	124,4
4	Excess air coefficient	C_{air}	in relative units	1,253	1,187	1,205
5	Air suction on the tract	ΔS_{air}	%	42,25	46,86	48,85
6	Gross efficiency	η_b	%	90,24	90,2	91,25
7	Specific consumption of electric energy for own needs	$E_{o.n.}$	%	2,349	2,505	2,464
8	Specific heat consumption for own needs	$Q_{o.n.}$	%	2,135	2,084	1,44
9	Net efficiency	η_n	%	84,1	82,74	83,96

The solution of problems carried out in an automated mode is preceded by the preparation of initial data, including the transformation of integral type indicators into specific indicators, the selection of independent indicators and their standardization [3]. Integral type indicators include indicators whose average value depends on the duration of work. The downtime of the SBI is caused by both cases of its emergency repair and the duration of downtime during scheduled repairs or in reserve due to failures of other installations of the power unit (steam turbine, turbo generator, block transformer, switches, auxiliary systems).

Let us note one important feature when preparing the list of SBI indicators. It is known that when classifying, including ranking objects, one of the main requirements is the independence of features (indicators) [4].

The assessment of the correlation between indicators with a small number m_Σ ranked SBI shows that to one degree or another, dependencies exist between almost all indicators [5].

Table 2: Quantitative assessments of technical and economic indicators of 300 MW power units

No SBI	Months of year	Technical and economic indicators								
		h_{ave}	T_{air}	T_{eg}	C_{air}	ΔS_{air}	η_b	$E_{o.n.}$	$Q_{o.n.}$	η_n
1	1	34,0	261	113	1,94	43,3	91,55	2,58	2,45	83,0
	2	34,9	280	111	1,13	43,3	89,16	4,05	1,57	76,3
	3	34,9	277	108	1,159	45	91,89	2,38	1,28	84,5
2	1	34,8	293	109	1,16	41	90,95	2,56	1,88	84,5
	2	34,7	304	123	1,197	46,7	91,84	2,11	1,71	84,1
	3	34,8	274	98	1,165	40,7	91,48	2,41	1,37	85,1
3	1	35,3	294	117	1,17	43	91,21	2,39	1,74	85,1
	2	34,6	295	123	1,228	43,8	90,69	2,33	1,78	84,6
	3	33,5	285	115	1,226	43,2	91,07	2,91	1,48	83,3
4	1	35,0	305	154	1,16	42,6	87,88	2,34	2,62	83,7
	2	34,9	298	147	1,217	51,3	89,29	2,52	2,75	82,3
	3	34,6	304	137	1,283	56,8	90,15	2,55	1,5	83,3
5	1	35,1	293	110	1,11	39,5	92,34	2,11	1,03	86,1
	2	34,7	300	109	1,097	41,2	93,6	1,98	0,96	86,6
	3	34,3	285	114	1,193	44,9	92,91	2,17	1,11	85,9
6	1	34,5	305	157	1,15	41,3	89,45	2,46	2,73	83,0
	2	34,5	301	158	1,182	47,1	88,66	2,4	2,76	81,9
	3	34,3	306	157	1,226	58	90,59	2,72	1,88	81,6
7	1	33,6	325	151	1,15	42,8	90,29	2,18	1,98	83,6
	2	34,7	282	141	1,204	49,5	89,77	2,34	2,74	83,0
	3	34,4	312	139	1,132	46	91,85	2,06	1,57	85,0
8	1	34,5	291	146	1,18	44,5	88,22	2,17	2,65	83,8
	2	34,9	289	143	1,239	52	88,62	2,31	2,4	83,1
	3	34,1	280	127	1,252	56,2	90,05	2,51	1,33	83,0

If we take into account the random nature of the change in the correlation coefficient Kr and take into consideration only those indicators for which $K_r > \overline{K}_{r,(1-\alpha)}$ or $K_r < \underline{K_{r,\alpha}}$, then the number of dependent indicators decreases. Here $\overline{K}_{r,(1-\alpha)}$ and $\underline{K_{r,\alpha}}$ are the boundary values of the statistical function of the fiducial distribution $F^*(K_r)$, calculated under the condition that the samples under consideration are obtained randomly from the general population [6]. When comparing K_r with boundary values with a given significance level α, for example, α=0.05, it is assumed that the number of comparisons is equal to one [7]. In the case when the comparison results assume n comparisons, then the reliability R=0.95 will correspond to $\overline{K}_{r,(1-\alpha)}$ and $\underline{K_{r,\alpha}}$, calculated for $\alpha_n=\alpha/n$ [8]. For example, for n=10 the value $\alpha_n<10^{-3}$, which corresponds to the value $\overline{K}_{r,\alpha_n}>0.95$. Consequently, for a small number m_Σ one should proceed not from condition $K_r > K_{r,\propto_n}$ but from condition $K_r > \overline{K_{r,\propto_n}}$ [9]. Such a relationship exists, for example, between the specific load of the SBI, the specific consumption of feedwater and the "Gross" heat consumption, between the temperature of the exhaust gases and the heat loss with the exhaust gases. The presence of a relationship between the indicators leads to an overestimation of the final quantitative assessment of the technical condition (K_L) of the most reliable and economical SBI and to a decrease in K_L for the least reliable and economical SBI.

The value of K_L is calculated using the formula:

$$K^{*}_{L,j} = n_{\Sigma}^{-1} \sum_{i=1}^{n_k} \frac{2[In_{i,j} - m_{\Sigma}^{-1} \sum_{j=1}^{m_{\Sigma}} In_{i,j}]}{L^{*}_{\Sigma}(In_i)} \quad (1)$$

where (In -Indicator),

$L^{*}_{\Sigma}(In_i) = (In_{i,max} - In_{i,min})$; $In_{i,max} = max\{In_{i,j}\} j = 1, m_{\Sigma}$; $In_{i,min} = min\{In_{i,j}\} j = 1, m_{\Sigma}$

As an example, Table 3 shows the results of calculating the $K^{*}_{L,j}$ grades for eight SBIs (j=1,8) with n_{Σ}=12, n_{Σ}=10 и n_{Σ}=9.

III. Results

Table 3: Results of the assessment of the influence of dependent SBI indicators on $K_{l,j}$

n_{Σ}	Conditional numbers of the SBI ES							
	1	2	3	4	5	6	7	8
12	-0.075	-0.25	-0.509	-0.043	0.467	0.112	0.41	-0.112
10	0.055	-0.244	-0.43	-0.003	0.341	0.074	0.428	-0.112
9	0.009	-0.163	-0.448	-0.077	0.418	-0.032	0.457	-0.161

As follows from Table 3, when moving from n_{Σ}=12 to n_{Σ}=10 and further to n_{Σ}=9, not only the value changes, but also the ranking result of the SBI.

Along with the above, in the ranking algorithm of the SBI it is necessary to take into account that in the spring-summer period there may be cases when one or more power units during the calculated time interval was in a state of planned repair or reserve. At the same time, the number of ranked SBI (m_{Σ}) decreases accordingly [10].

IV. Discussion

I. Formation of the main directions for increasing the efficiency of the SBI work in the next billing period of work

The calculation results include:

- a sequence of power plant SBI ordinal numbers ranked by efficiency. Calculated in accordance with [1]
- a list of technical and economic indicators, ranked by importance, recommended for improvement for each SBI
- quantitative assessment of the significance of these indicators $\delta In_{i,j}$
- average quantitative assessment of these indicators for the period under review $In_{i,j}(\Delta\tau)$
- averaged over the period under review for all SBI quantitative assessment of these indicators $M^{*}[In_i(\Delta\tau)]$

In conclusion, the main results and recommendations are formulated, namely:

- a quantitative assessment of the technical condition of the operating SBI is provided
- the least efficient power plant SBI is installed. This SBI is recommended for shutdown for scheduled maintenance, and beforehand - for shutdown in reserve or for the maximum possible reduction of its load
- the load of this SBI must be the maximum permissible

- the number ($m^{(+)}$) and the list of "good" SBI are established, for which the quantitative assessment of the technical condition $\delta In_i(\Delta\tau)$ is positive. An increase in their productivity is allowed in proportion to the relative values of $\delta In_i(\Delta\tau)$. The relative values of $\delta In_i(\Delta\tau)$ are calculated using the formula

$$\delta^* In_i(\Delta\tau) = \frac{\delta In_i(\Delta\tau)}{\sum_{i=1}^{m^{(+)}} \delta In_i(\Delta\tau)} \quad (2)$$

- the number $m^{(-)}$ and the list of "bad" SBI are established, for which $\delta In_i(\Delta\tau) < 0$. It is recommended to reduce their load inversely proportional to their relative values

$$\delta^* In_i(\Delta\tau) = \frac{\delta In_i(\Delta\tau)}{\sum_{i=1}^{m^{(-)}} \delta In_i(\Delta\tau)} \quad (3)$$

- the main reasons for the decrease in the efficiency of the power plant SBI are formed

It should be noted that at the initial stage of implementation of the automated control system, the "weak links" of the control system are established based on tolerance $\delta In_{i,j} > 10\%$. Subsequently, this tolerance can be reduced to 5% [11].

II. Control of the efficiency of the SBI mode management

This control allows us to evaluate the work of personnel to improve the technical and economic indicators of the SBI for the past period. In practice, for a number of indicators (T_{eg}, C_{air}, ΔS_{air}, $Q_{o.n}$, η_n) this control is carried out according to calculated standard indicators that correspond to the energy characteristics of each SBI. However, as the service life of the SBI increases, the initial energy characteristic is transformed. Insufficient consideration of this change leads to the fact that the error in the standard values of the indicators increases. This is reflected in a significant discrepancy between the actual values of the indicators and the standard values. As the service life of the SBI increases, its personnel have fewer and fewer opportunities to maintain indicators equal to the original values. Without changing the existing control system, it is proposed to pay special attention to the "weak links" of the SBI, ensuring the equality of the actual values of the indicators of no less than the arithmetic mean value of the indicators for all similar SBIs of the power plant. In most cases, this result can be achieved by increasing the attention to them by the operating personnel.

The quality of management is assessed based on data on changes in the values of indicators for the period preceding the current calculated period of work $\Delta\tau_k$. Increasing the accuracy of the quantitative assessment of the quality of management, and especially the result of comparing the quality of management of various indicators, can be achieved by switching to calculating the relative magnitude of the change in indicators $\beta In_{i,j}(\Delta\tau)$ and taking into account the measurement error or calculation of indicators G_i. The value of $\beta In_{i,j}(\Delta\tau)$ is supposed to be calculated using the formula with the increase of $In_{i,j}(\Delta\tau)$ the efficiency of the SBI increases.

$$\beta In_{\mathrm{i,j}}(\Delta\tau_{k-1}) = \frac{In_{\mathrm{i,j}}(\Delta\tau_{k-1}) - In_{i,j}(\Delta\tau_{k-2})}{In_{\mathrm{max,i}}(\Delta\tau_{k-2}) - In_{min,\,i}(\Delta\tau_{k-2})} \tag{4}$$

Otherwise

$$\beta In_{\mathrm{i,j}}(\Delta\tau_{k-1}) = \frac{In_{\mathrm{i,j}}(\Delta\tau_{k-2}) - In_{i,j}(\Delta\tau_{k-1})}{In_{\mathrm{max,i}}(\Delta\tau_{k-2}) - In_{min,\,i}(\Delta\tau_{k-2})} \tag{5}$$

In this case, if $\beta In_{i,j}(\Delta\tau_{k-1}) > 0$, then switching off the SBI to reserve and fulfilling the conservation requirement led to an increase in the efficiency of the SBI, and if $\beta In_{i,j}(\Delta\tau_{k-1}) < 0$, then to a decrease in the reliability and cost-effectiveness of the operation. The calculation results for each SBI ($j = 1, m_\Sigma$) include:

- conventional numbers and names of the considered $i = 1, n_\Sigma$ technical and economic indicators
- averaged over the calculation period $\Delta\tau_{k-2}$ quantitative estimates of these indicators $In_{i,j}(\Delta\tau_{k-2})$ with $i = 1, n_\Sigma$
- averaged over all SBI for period $\Delta\tau_{k-2}$ quantitative estimates of these indicators $M^*[In_i(\Delta\tau_{k-2})]$ with $i = 1, n_\Sigma$
- averaged over the calculation period $\Delta\tau_{k-1}$ quantitative estimates of these indicators $In_{i,j}(\Delta\tau_{k-1})$ with $i = 1, n_\Sigma$
- assessment of the quality of management

The assessment of the quality of management is classified into five types: 1-unacceptable; 2-bad; 3-satisfactory; 4-good; 5-indicative and is determined based on the following conditions, which contribute to understanding the quantitative assessment of the quality of management:

1. $J1 = J1 + 1, if\ J1 > N, then\ 37$
2. $if\ R_{1,i} < 0, then\ 20$
3. $if\ In_{i,j}(\Delta\tau_{k-2} > M^*[In_i(\Delta\tau_{k-2})], then\ 12$
4. $if\ In_{i,j}(\Delta\tau_{k-2}) \neq In_{i,min}(\Delta\tau_{k-2}), then\ 8$
5. $if\ In_{i,j}(\Delta\tau_{k-1}) < In_{i,j}(\Delta\tau_{k-2}), then\ J_i = 2 \to 1$
6. $if\ In_{i,j}(\Delta\tau_{k-1}) < M^*[In_i(\Delta\tau_{k-2})], then\ J_i = 3 \to 1$
7. $if\ In_{i,j}(\Delta\tau_{k-1}) < In_{i,max}(\Delta\tau_{k-2}), then\ J_i = 4 \to 1,$ $Otherwise\ J_i = 5 \to 1$
8. $if\ In_{i,j}(\Delta\tau_{k-1}) < In_{i,min}(\Delta\tau_{k-2}), then\ J_i = 1 \to 1$
9. $if\ In_{i,j}(\Delta\tau_{k-1}) < In_{i,j}(\Delta\tau_{k-2}) then\ J_i = 2 \to 1$
10. $if\ In_{i,j}(\Delta\tau_{k-1}) < M^*[In_i(\Delta\tau_{k-2})], then\ J_i = 3 \to 1$
11. $if\ In_{i,j}(\Delta\tau_{k-1}) < In_{i,max}(\Delta\tau_{k-2})\ then\ J_i = 4 \to 1, Otherwise \to J_i = 5 \to 1$
12. $if\ In_{i,j}(\Delta\tau_{k-2}) \neq In_{i,max}(\Delta\tau_{k-2})\ then\ 16$
13. $if\ In_{i,j}(\Delta\tau_{k-1}) > In_{i,max}(\Delta\tau_{k-2})\ then\ J_i = 4 \to 1$
14. $if\ In_{i,j}(\Delta\tau_{k-1}) > M^*[In_i(\Delta\tau_{k-2})], then\ J_i = 3 \to 1$
15. $if\ In_{i,j}(\Delta\tau_{k-1}) > In_{i,min}(\Delta\tau_{k-2})\ then\ J_i = 2 \to 1, Otherwise \to J_i = 1 \to 1$
16. $if\ In_{i,j}(\Delta\tau_{k-1}) > In_{i,max}(\Delta\tau_{k-2})\ then\ J_i = 5 \to 1$
17. $if\ In_{i,j}(\Delta\tau_{k-1}) > In_{i,j}(\Delta\tau_{k-2})\ then\ J_i = 4 \to 1$
18. $if\ In_{i,j}(\Delta\tau_{k-1}) > M^*[In_i(\Delta\tau_{k-2})], then\ J_i = 3 \to 1$
19. $if\ In_{i,j}(\Delta\tau_{k-1}) > In_{i,min}(\Delta\tau_{k-2})\ then\ J_i = 2 \to 1, Otherwise \to J_i = 1 \to 1$
20. $if\ In_{i,j}(\Delta\tau_{k-2}) > M^*[In_i(\Delta\tau_{k-2})], then\ 29$
21. $if\ In_{i,j}(\Delta\tau_{k-2}) \neq In_{i,min}(\Delta\tau_{k-2}), then\ 25$
22. $if\ In_{i,j}(\Delta\tau_{k-1}) < In_{i,j}(\Delta\tau_{k-2}), then\ J_i = 4 \to 1$
23. $if\ In_{i,j}(\Delta\tau_{k-1}) < M^*[In_i(\Delta\tau_{k-2})], then\ J_i = 3 \to 1$
24. $if\ In_{i,j}(\Delta\tau_{k-1}) < In_{i,max}(\Delta\tau_{k-2})\ then\ J_i = 2 \to 1, Otherwise \to J_i = 1 \to 1$
25. $if\ In_{i,j}(\Delta\tau_{k-1}) < In_{i,min}(\Delta\tau_{k-2}), then\ J_i = 5 \to 1$
26. $if\ In_{i,j}(\Delta\tau_{k-1}) < In_{i,j}(\Delta\tau_{k-2}), then\ J_i = 4 \to 1$
27. $if\ In_{i,j}(\Delta\tau_{k-1}) < M^*[In_i(\Delta\tau_{k-2})], then\ J_i = 3 \to 1$
28. $if\ In_{i,j}(\Delta\tau_{k-1}) < In_{i,max}(\Delta\tau_{k-2})\ then\ J_i = 2 \to 1, Otherwise \to J_i = 1 \to 1$
29. $if\ In_{i,j}(\Delta\tau_{k-2}) \neq In_{i,max}(\Delta\tau_{k-2})\ then\ 33$
30. $if\ In_{i,j}(\Delta\tau_{k-1}) > In_{i,max}(\Delta\tau_{k-2}), then\ J_i = 2 \to 1$
31. $if\ In_{i,j}(\Delta\tau_{k-1}) > M^*[In_i(\Delta\tau_{k-2})], then\ J_i = 3 \to 1$
32. $if\ In_{i,j}(\Delta\tau_{k-1}) > In_{i,min}(\Delta\tau_{k-2})\ then\ J_i = 4 \to 1, Otherwise \to J_i = 5 \to 1$
33. $if\ In_{i,j}(\Delta\tau_{k-1}) > In_{i,max}(\Delta\tau_{k-2}), then\ J_i = 1 \to 1$
34. $if\ In_{i,j}(\Delta\tau_{k-1}) > In_{i,j}(\Delta\tau_{k-2}), then\ J_i = 2 \to 1$
35. $if\ In_{i,j}(\Delta\tau_{k-1}) > M^*[In_i(\Delta\tau_{k-2})], then\ J_i = 3 \to 1$
36. $if\ In_{i,j}(\Delta\tau_{k-1}) > In_{i,min}(\Delta\tau_{k-2})\ then\ J_i = 4 \to 1, Otherwise \to J_i = 5 \to 1$
37. Exit

Figure 1: The fragment of management quality assessment

The conclusion includes:

- quantitative assessments of the quality of control of the work of the power plant SBI.
- results of the ranking of SBI by quality of management and their comparison with the sequence of SBI numbers ranked by technical condition
- information about the SBI with the highest and worst management quality
- information on the nature of changes in technical and economic indicators during intuitive management of the efficiency of the SBI

It should be noted that the algorithm for assessing the quality of management determines the qualifications of personnel in implementing recommendations to improve the efficiency of the SBI. If these recommendations are missing, then a comparison of technical and economic indicators for (k-2) and (k-1) calculation periods allow us to assess the quality of management of the SBI efficiency with the existing approach.

III. Assessment of the technical condition of the SBI

When the SBI is inoperative (except for its emergency or scheduled repair), the efficiency of subsequent operation largely depends on the fulfillment of the requirements for one of the reliability properties – storability, SBI. Ensuring the storability of the SBI is reduced not only to preventing failure during start-up from a non-working state, but also to the deterioration of its technical and economic indicators. In order to assess the degree of storability of the SBI during its successful start-up from a non-working state, it is necessary to compare the average values of the SBI performance indicators before shutdown (b) and after (a) start-up. For example, averaging of indicators can be carried out a week before stopping the SBI and during the week after startup. It should be noted that the greatest interest is not relatively short-term, but long-term SBI downtime. These primarily include switching off power units to a reserve. Considering that, as a rule, the least reliable and economical power units are and should be switched off to a reserve, and consequently, the least reliable and more economical SBI, the relevance of the storability problem becomes even more significant.

The degree of protection of the SBI from environmental impacts in a state of downtime (power unit shutdown to reserve) is assessed on the basis of the above algorithms with the small difference that:

- instead of indices (k-2) and (k-1), indices "b" and "a" should be introduced, denoting, respectively, the value of the indicators before and after the SBI downtime
- indicators $In_{i,j}(\Delta\tau_b)$, $In_{i,min}(\Delta\tau_b)$, $In_{i,max}(\Delta\tau_b)$ and $M^*[In_i(\Delta\tau_b)]$, as well as when solving the first two problems, are calculated for the value $\Delta\tau_b = 1\ month$, adopted in energy systems, and indicators $In_{i,k}(\Delta\tau_a)$ – for $\Delta\tau_a$, equal to one week
- the calculation is carried out not for all, but for one specific SBI, which is part of the power unit that has been put into reserve
- conclusions and recommendations are changing

The conclusion includes:

- resulting assessment of the sustainability of the SBI
- relative number (%) assessment of indicators:
- with indicators deteriorated during the period of downtime in reserve
- with constant quantitative estimates
- with improved performance indicators during the downtime in reserve
- list of indicators with quantitative assessments worsened in the downtime period

Information about these changes is very important both for improving the SBI preservation system and when planning SBI repairs. The experience of comparing indicators confirms the relevance of the problem of improving the quality of SBI preservation during downtime.

IV. Assessment of the quality of scheduled maintenance

The reliability and efficiency of the SBI operation largely depend on timely scheduled repairs and their quality. The organization of scheduled repairs taking into account the technical condition of the SBI provides the possibility of systematizing information on changes in quantitative estimates of technical and economic indicators during the inter-repair period. It is the dynamics of changes in these indicators, together with average values, that are one of the conditions for the feasibility of restoring the wear of individual SBI units.

Timely implementation of scheduled maintenance even for the technical condition of the SBI does not yet ensure an increase in the efficiency of its operation. The efficiency of operation is ensured only by the good quality of scheduled maintenance. The quality of the repair is assessed automatically in accordance with fragments of the algorithms, similar to the assessment of the storability of the SBI with some natural difference in the table of results of the calculation of the conclusion and recommendation. Unlike the assessment of the quality of control of the SBI modes, the assessment of the quality of the scheduled maintenance of the SBI is equated to the worst assessment of the quality of repair of its individual units. The choice of an average assessment to characterize the quality of the SBI repair is erroneous. Average assessments are higher, but less plausible. The nature of the change in these curves during the inter-repair period $In_{i,j}(\Delta\tau) = f^*(t)$ for one of the SBI and a number of indicators is shown in Figure 2.

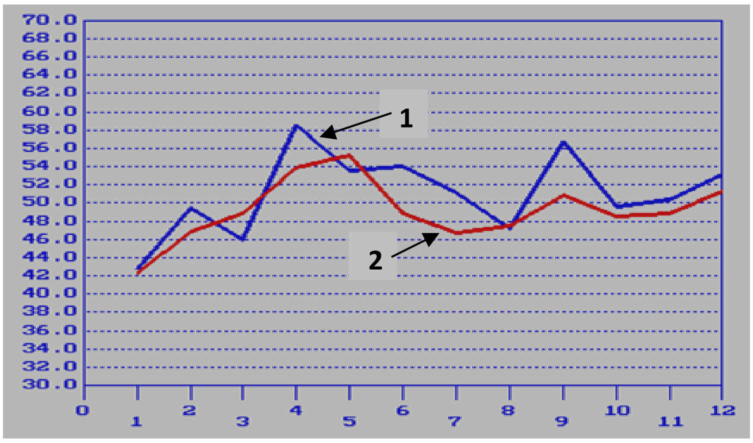

Figure 2: Nature of air suction change during the inter-repair period for values: 1 – actual SBI; 2 – averaged over all SBI.

If the $In_{i,j}(\Delta\tau) = f^*(t)$ curves help to identify the time for scheduled maintenance, then the analysis of the "weak links" – the volume of scheduled maintenance.

Example: It is required to rank the SBIs by technical condition, to establish the most and least efficient SBIs, to identify the main directions for increasing the reliability and efficiency of the power plant SBI operation. The results of calculations based on the data in Tables 1 and 2 for the first month are shown in the following.

No SBI	Technical and economic indicators			
	Name	Relat.dev. mean	Actual val.	Recom. val.
1	Excess air coefficient	-1.657	1.94	1.25
1	Specific load	-1.154	34.00	34.75
1	Air temperature after RAH	-1.090	261.00	295.88
1	Specific consumpt of EE for O.N.	-.984	2.58	2.35
1	Net efficiency	-.710	83.00	84.10
1	Air suction on the tract	-.420	43.30	42.25
1	Specific heat consumpt for O.N.	-.371	2.45	2.14
2	Specific consumpt of EE for O.N.	-.899	2.56	2.35
3	Air suction on the tract	-.300	43.00	42.25
3	Specific consumpt of EE for O.N.	-.176	2.39	2.35
4	Gross efficiency	-1.113	87.88	90.36
4	Exhaust gas temperature	-.911	154.00	132.12
4	Specific heat consumpt for O.N.	-.571	2.62	2.14
4	Net efficiency	-.258	83.70	84.10
4	Air suction on the tract	-.140	42.60	42.25
6	Exhaust gas temperature	-1.036	157.00	132.12
6	Net efficiency	-.710	83.00	84.10
6	Specific heat consumpt for O.N.	-.700	2.73	2.14
6	Specific consumpt of EE for O.N.	-.473	2.46	2.35
6	Gross efficiency	-.409	89.45	90.36
7	Exhaust gas temperature	-.786	151.00	132.12
7	Net efficiency	-.323	83.60	84.10
7	Air suction on the tract	-.220	42.80	42.25
8	Gross efficiency	-.960	88.22	90.36
8	Air suction on the tract	-.900	44.50	42.25
8	Specific heat consumpt for O.N.	-.606	2.65	2.14
8	Exhaust gas temperature	-.578	146.00	132.12
8	Specific load	-.231	34.60	34.75
8	Net efficiency	-.194	83.80	84.10
8	Air temperature after RAH	-.291	291.00	295.88

CONCLUSION: The results of the calculations allowed us to establish and recommend:

1. Quantitative assessments of the technical condition (TC) of the SBI are equal to:

No. SBI	1	2	3	4	5	6	7	8
Assess. TC	-.562	.195	.274	-.263	.744	-.26	.171	-.296

2. The least efficient of the operating should be considered 1 SBI. It is recommended to disconnect for scheduled maintenance, and beforehand - to disconnect for reserve or to reduce the load as much as possible
3. The most effective is 5 SBI. It is advisable to work with the maximum permissible productivity
4. The group of "good" includes ,5,3,2,7 SBI. It is allowed to increase their productivity in proportion to the relative values of the coefficients of significance of the technical condition
5. The group of "bad" includes ,1,8,4,6, SBI. It is recommended to reduce the load inversely proportional to the relative values of the coefficients of significance of the technical condition
6. The main reasons for the decrease in efficiency of all SBI ES are:
   - Air suction on the tract
   - Net efficiency

Conclusions

1. Methods, algorithms and programs have been developed for improving the reliability and efficiency management system of power unit SBIs, allowing, based on the results of measuring and calculating technical and economic indicators:
   - obtain a quantitative assessment of the technical condition of the SBI
   - evaluate the results of operational management of the operating modes of the control system
   - calculate the durability of the technical condition of the SBI during downtime
   - to formulate a strategy for the planned repair of the SBI and to assess the quality of the repair

2. The developed method allows us to consider the obtained results as methodological support for personnel in organizing the operation, maintenance and repair of SBI

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