TECHNICAL SCIENCES

DETERMINATION OF THE RESOURCE CAPABILITIES OF INDUSTRIAL BOILERS

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Abstract
The publication describes the structure of the types of costs that influence the assessment of the durability of industrial boilers. Graphs for changes in costs during operation of boilers are presented. An analysis of the costs of elements of industrial boilers that cannot be repaired in case of boiler failure is presented

Keywords: Industrial boilers; Resource of industrial boilers; Determination of technical and economic indicators of industrial boilers

1. Introduction

The resource is the ability of an industrial boiler to maintain its operability for a certain period of time, and this period is limited to the occurrence of a certain condition of the boiler elements.

The resource of an industrial boiler is a complex quantity and depends on many factors, incl. structural, technological, climatic, etc. It is possible that boilers of the same type and model have a different resource, i.e. there is a resource with a large distraction. For this reason, and in order to obtain sufficiently reliable information, it is necessary to monitor and study all possible data during operation. These data are collected and processed statistically by taking a representative sample with a sufficiently large volume of data and as a result of their processing, the average duration of trouble-free operation of the boiler until the need for major repair and distraction characteristics of this major repair.

Ideally, all individual elements and units of an industrial boiler would simultaneously reach their maximum operating cycle, but this is practically impossible as they have different values, which also affects the boiler as a whole.

The operational resource of an industrial boiler must be determined already during its design and construction, using the experience gained so far from the operation of other similar boilers. Along with this, the economic indicators related to the creation of the boiler should be taken into account, since they determine the optimal resource of the boiler. The optimal resource represents the amount of operating costs that can be achieved at a minimum value for their realization.

2. Impact and influence of operating costs when determining the resource of industrial boilers

The various indicators of trouble-free operation of the boiler are determined by the probability of a failure occurring during their operation, as well as by some other technical and economic criteria, determining the total value of the minimum costs associated with the elimination of the causes of the occurrence of failures and restoration of normal boiler operation. These costs can be one-time, periodic and permanent.

Periodic costs are incurred when it is necessary to remove the failure in one of the boiler's elements. This failure must have occurred as a result of reaching the maximum limit value of the corresponding parameter in the period between two preventive services. Along with this, these costs also include those that can be carried out during routine preventive activities.

Permanent costs are those that arise as a result of a change in the state parameters of the industrial boiler. These costs are directly related to the wear and tear of the elements, leading to a reduction in the boiler's power, as well as to an increase in fuel consumption to produce the necessary thermal energy. Since the industrial boiler is an independent system, in order to reduce these costs, a certain maximum value of each individual parameter affecting the normal operation of the system must be assumed and thus limit the operation of the individual element, unit and unit in one normal range of safe and trouble-free operation.

To ensure a high degree of reliability of the system, the designer must know all the elements and materials that they plan to use When it has more than one element or unit that it can use, they must analyze and compare its design features and reliability characteristics in order to select the most applicable component for the facility they design, ensuring a high degree of reliability and safety and ensuring the longest possible period of normal operation before reaching a state of failure.

3. Costs of items that cannot be repaired

These costs vary depending on the cost structure of the production costs of the industrial boiler for the period of its use.

For convenience, we can define an element that cannot be repaired as a “peculiar element”, and the corresponding costs for it and the time for its operation as “peculiar costs” and “peculiar time”.

The cost of purchasing a peculiar element must be evenly distributed over the entire period of operation of the boiler, after which this item must be scrapped If we assume that the amount of work performed by this peculiar element remains constant throughout the entire service life, then the cost of this peculiar element will be proportional to the time of its use.

$$S_1 = \frac{\Sigma K_c}{T} \quad (1)$$

- S_1- costs for the peculiar element
- ΣK_c - total cost of purchasing, shipping and storing the peculiar element

These costs do not include the residual value of the peculiar element, which is obtained after its scrapping.

- **T** - service life of the peculiar element

As a result, it can be said that if there are no additional costs in the period of operation of the peculiar element, then the cost value ***S*** will decrease with increasing time ***T***.

3.1 Total costs for the peculiar element

These total costs for a peculiar element can be calculated by taking into account the total cost of purchasing, transporting and storing the feature and the operating costs of labour and materials.

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$$K_{ce} = \Sigma K_c + \Sigma K_e \quad (2)$$

- K_{ce} - total costs for the purchase and operation of the element
- ΣK_c - total costs for the purchase, transportation and storage of the element

These costs do not include the residual value of the peculiar element, which is obtained

after its scrapping.

- ΣK_e - operating costs for labour and materials

Assuming that the operating costs are proportional to the operating time of the peculiar element, the total cost of the feature will be:

$$S_2 = \frac{\Sigma K_c}{T} + \frac{\Sigma K_e}{T} = \frac{\Sigma K_{ce}}{T} = S_1 + S_e \quad (3)$$

- S_2 - operating costs of the peculiar element per unit time

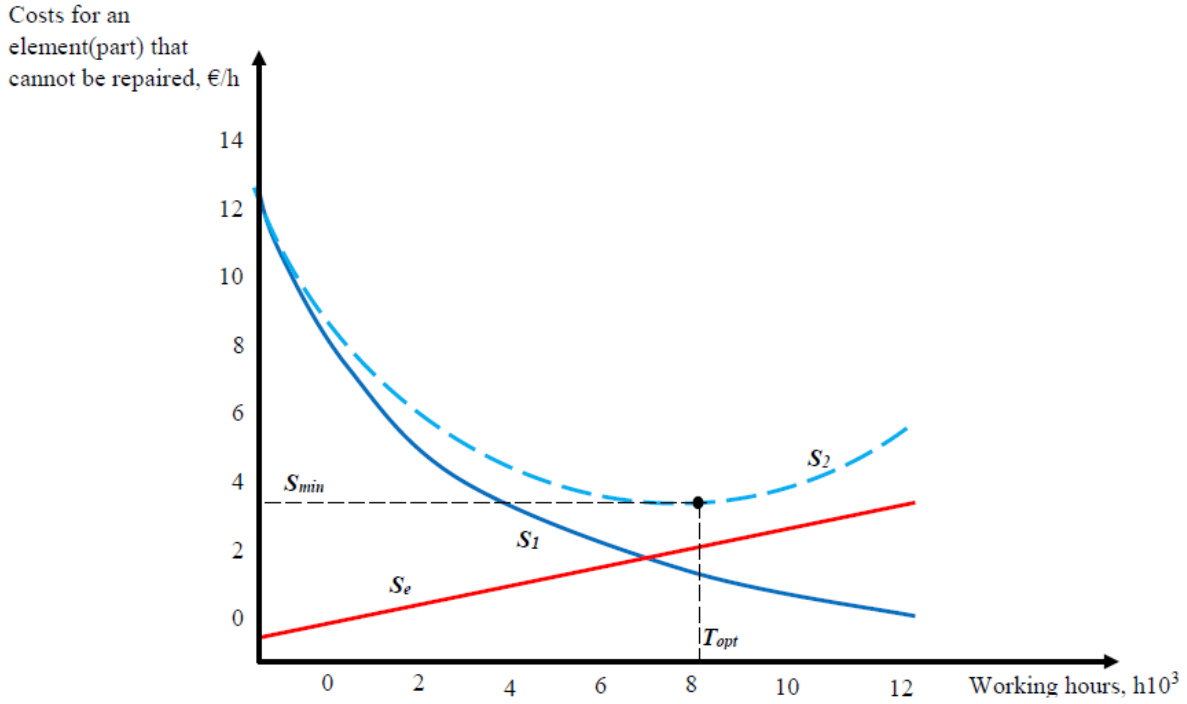

Figure 1 - Change of total costs depending on the duration of operation of the peculiar element

Figure 1 shows the change in total costs for a peculiar element depending on the length of the period of its use. From what is shown in Figure 1, it can be found that a minimum value of the peculiar cost can be achieved for the optimal time T_{opt}. The operating period of the peculiar element T_{opt}, in which the peculiar costs have a minimum value, represents the optimal resource of the peculiar element.

3.2 Total costs for the peculiar elements in industrial boilers in the event of increasing costs for their maintenance

The total cost of maintaining a peculiar element as part of an industrial boiler is determined by the amount of initial purchase, transport and storage costs and by the incremental costs arising from reduced useful life as a result of wear and tear of the peculiar element, as well as from reduction of the period of time of operation without failures or from increasing the operating costs and the costs of technical support and service.

Increasing peculiar costs S_{in} can be defined as follows:

$$S_{in} = kT^n \quad (4)$$

- k - coefficient determining the increasing change
- T^n – time to use the peculiar element in the construction of the industrial boiler in the period of increasing peculiar costs

The peculiar costs S_3 calculated per unit of time are determined by the peculiar costs of purchasing, transporting and storing the new peculiar element S_1, by the peculiar operating costs S_e, which change in

proportion to the period of normal operation, and by the increasing peculiar costs S_{in} .

$$S_3 = \frac{\Sigma Kc}{T} + \frac{\Sigma Ke}{T} + \frac{kT^n}{T} = S_1 + S_e + S_{in} \quad (5)$$

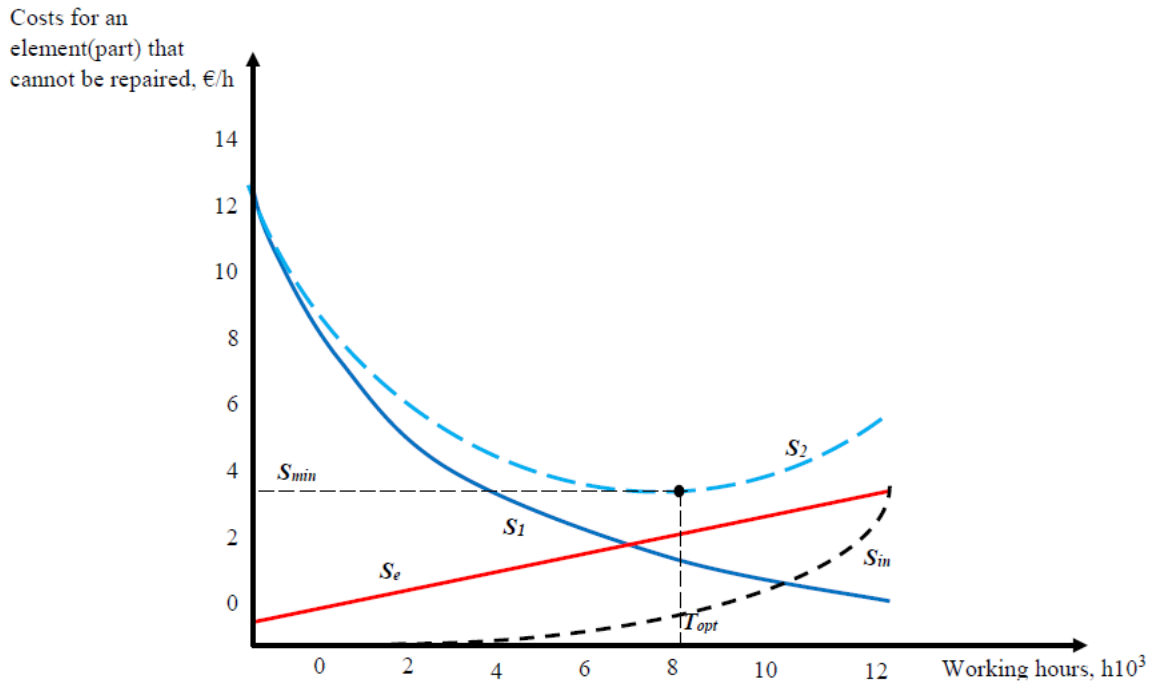

Figure 2 - Change of the amount of peculiar costs for the time of duration of operation in case of increasing

It can be seen from Figure 2 that in a certain period of time the total peculiar costs can get a minimum value. This particular period of time represents the optimal resource of the peculiar element.

3.3 Total costs when restoring the operability of the peculiar element in industrial boilers

In order to achieve a specific result when determining the total costs when restoring the normal operation of a peculiar element in an industrial boiler, it is necessary to calculate the average costs that will occur when the system enters this state.

$$K_{av} = k_1.K_{hr}.t_s + k_2.K_{sp} + K_l.t_l + K_d + K_{ic} \quad (6)$$

- k_1 - coefficient for accruals on salaries
- t_s - duration of the repair when removing damage
- K_{hr} - average hourly rate of the worker who is engaged in the activity of the normal operation of the peculiar element
- k_2 - coefficient for the cost of materials used in the repair to restore the normal operation of the peculiar element
- K_{sp} - cost of spare parts used in the repair to restore normal operation of the peculiar element
- K_l - average industrial boiler downtime losses
- t_l - average downtime of the industrial boiler when a failure occurs
- K_d - costs of delivery of spare parts and materials to the place of repair
- K_{ic} - permanent costs incurred as a result of changing the parameters, changing the processing technology and reducing the economic indicators of the industrial boiler

Losses from emergency repairs of the industrial boiler are formed under the influence of various factors. Their change can be observed in a rather wide spectrum of change. To correctly predict and achieve a longer period of operation without the boiler entering a failure state, it is necessary to evaluate a maximum number of possible causes. The achievement of the main goals for reliable and trouble-free operation of the industrial boiler, as well as the better planning of the cycle of its normal operation and the corresponding costs for guaranteeing this process, also depend on the correct choice of the influencing causes.

References:

1. Kolarov I., Lazarov I., Ensuring the reliability of the machines when constructing, Sofia, 1981.
2. Pronikov A.S., Reliability of machines, Machine building, Sofia, 1978.
3. Kolarov I., Kuzmov D.,Vachkov S., Heruvimov G., Mechanical systems reliability, Sofia, 1981
4. Bobrov, I.K., Method for calculating the required guaranteed number of spare elements for the operation of recoverable systems, Moscow, Ship Electronics, 1995
5. Nedev A., Dimov V., Kanev D., Genadiev G., Naumov V., Kamberov D., Reliability and diagnostics of thermal energy and transport machines, Maleo 63, Varna, 2005.
6. Kostetsky, B.I., Reliability and durability of machines, K, Technics, 1975