Suggestions for improving the efficiency of repair activity

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Abstract. In order to improve the organization and performance of equipment maintenance, innovative proposals were developed and implemented. The explanations were taken into account when determining the methods for evaluating the maintenance performed for the joint approval of a unified methodology of applying the concept of a standard hour. The planning of performing equipment maintenance by day during the whole month was revised, which, in turn, allowed minimizing significant fluctuations in the scope of work and eliminating peak loads. The works on the maintenance of the mechanical and energy components of a single assembly were revised and combined as much as possible, which ensured the more efficient use of working time. Work has been organized on updating the composition of the operations to be performed, since the scope of maintenance work in the assignment forms is not always representative of the complex of necessary operations. Preventive work with subordinate personnel is organized in the field of improving the industrial standards in the workplace.

1. Introduction

Maintenance is the main preventive measure necessary to ensure reliable operation of equipment between scheduled maintenance and reduction of the total amount of repair work. It provides for supervision of equipment operation, equipment care, maintaining the equipment in good condition, scheduled technical inspections. As a rule, regulated maintenance is performed by the operational and repair personnel of the enterprise.

Recently, in the industrial manufacturing sector, order placement for equipment maintenance services have increased in various measurement systems. Many large enterprises are developing their own information and analytical reference books that represent the costs of performing certain kinds of repair for equipment.

Unfortunately, the existing regulatory framework for the maintenance of the equipment does not provide for the standardizing of each operation that can be carried out as part of the maintenance (the number of the equipment in use reaches tens and sometimes hundreds of thousands of items).

2. Results and discussion

The complexity of the repair work of a particular type is determined based on the number of units of repair complexity and the time norms established for one repair unit. The number of units of repair complexity in the mechanical part of the equipment coincides with the category of complexity. The following technical and economic indicators are used in the analysis and evaluation of the repair service:

- Downtime of equipment under repair per one repair unit. This indicator is determined by dividing the total downtime of equipment under repair by the number of repair units of
equipment that is being repaired in a given planning period. It is necessary to maximally reduce this time.

- The number of repair units of installed equipment per one repair worker. This number characterizes the labor productivity of repair workers, which should constantly increase.
- The cost of repairing one repair unit, determined by dividing all costs (including delivery notes) for repairs during a certain time (for example, during a year) by the number of repair units of equipment repaired during the same planned period.
- The turnover of the stock of spare parts, which is equal to the ratio of the cost of consumed spare parts to the average balance of them in the storerooms. This indicator should be as big as possible.
- The number of accidents, breakdowns and unscheduled repairs per unit of equipment, which characterizes the efficiency of the planned preventative repair system. It should be minimal.

There is a definite relationship between these indicators. Reduction of equipment repair downtime per one repair unit results in an increase in the number of repair units of installed equipment per repair worker, since the same amount of repair work while reducing time for it can be performed by fewer workers. This leads to a reduction in the cost of repairing one repair unit. The first three indicators are improved through a more efficient organization of repairs and maintenance, which results in an improvement in the fourth indicator. All indicators are analyzed in comparison with the indicators achieved at specialized repair shops [1–6].

The indicator of the cost of normalized working time for rendering services is the normative labor intensity, which is set in standard hours. The number of standard hours required for the manufacture of products/services, is determined by summing up the technically feasible standards of time for all process flow operations. Thus, the customer forms a production program (in standard hours) for the repair company. In this connection, the customer is not able to objectively estimate the scope of work of any unfulfilled (as unnecessary) operation. When conducting an internal audit, the customer, as a rule, checks the availability of human resources (maintenance personnel) at workplaces, thereby determining the number of man-hours worked: the actual cost of working time for rendering services, that is, the actual labor intensity.

As a result, under certain conditions of equipment maintenance, instead of an approved unit of measure for maintenance (a standard hour) the customer uses the number of hours worked by staff, i.e., a kind of “substitution” of indicators occurs when the number of man-hours is deemed to be standard hours.

For clarity, it is proposed to consider the following situation on the conditional example of an enterprise engaged in the maintenance of industrial gearboxes.

For proper maintenance of gearboxes, there is a final list of possible operations to be performed, for which the average standard length of time in hours is established, used only to determine the cost of the contractor for maintenance. The result of the technician's work is a serviceable gearbox, and it is not necessary to perform the entire list of operations to achieve these goals. The list of operations, as well as the time and volume of impact, in each case is determined individually, taking into account the operating conditions, the repair system, and the qualification of the process and maintenance personnel.

Payment for the services of a technician is determined by the price list of his company in accordance with the following entry: maintenance of one gearbox (brand, type and other identification features) is 1,700 rubles regardless of the actual time spent. If the service company carries out maintenance by hundreds of thousands of objects, then their enumeration in the annually approved price list is not appropriate. The price list approves the value of any conditionally constant value, in this case, the cost of a standard hour. A quantity of these values, which measure the result of the maintenance of one unit of equipment, is established by the local reports, which do not require systematic revision.

Estimating effectiveness of measures on increasing the labor productivity is defined as the ratio of actual labor expense to the normative labor expense:

\[ K_{ef.} = \frac{T_{act}}{T_{norm}} \]  

(1)
To convert the normative labor input into actual time expenditure, it is adjusted with the help of the labor performance, which directly depends on the qualifications of workers and the engineering and technical level of the enterprise. The actual labor intensity of production is calculated by dividing the working time spent in man-hours by the total volume of production in actual or cost measurements [7–12].

Labor productivity is an indicator of labor resource efficiency. It is measured by the number of products, works in kind or in value terms, produced by one employee for a certain time. One of the methods of measuring labor productivity is labor method, based on the calculation of the labor intensity of each product, as well as work. According to this method, labor efficiency is estimated by comparing actual costs with standard costs.

As it follows from the definition of the meaning of the standard hour, this term refers to the section of the economics (labor economics), which studies the processes of reproduction of the labor and the interaction of workers, problems of productivity and efficiency of labor, methods of substantiating the number of employees, etc.

The analysis of publicly available information sources, a summary of the experience of using for the mutual calculations of standard hours by repair companies suggests that the standard hour is a unit of normative labor intensity that differs from the astronomical concept of an hour. This is the value to which the price is linked and the cost of the technical maintenance unit of equipment is obtained. Otherwise, it is necessary to calculate the cost of maintenance of each unit of equipment by making direct calculations, which in turn impedes the task of planning maintenance costs and monitoring their execution.

The standard hour indicator is used in various fields of activity, for example, when evaluating the work of programmers, managers, university professors, etc. Representatives of creative professions (writers, composers, artists) may have a tenfold difference in productivity, since the potential labor productivity of each person is different: the man-hour of different specialists has different returns, which depend on personality type, education, experience, talent and other qualities of a specific person and changes over time [13–17].

The indicator of service in standard hours was widely adopted at car care enterprises to determine the complexity of performing a car repair operation. The total cost of car care services, excluding the cost of spare parts and materials used in the repair, is defined as the product of the number of standard hours and the cost of one standard hour [18–22].

In order to determine the assessment of the effectiveness of equipment maintenance by the repair company, an internal audit was conducted, taking into account the organization of the operation of the maintenance system and the processing of the necessary documentation.

During the period of the audit, the following measures were implemented to improve the efficiency of high-quality maintenance:

- lists of shop equipment of the enterprise were determined and personally assigned with internal orders to the workers of the repair sites via their signature;
- flow charts for maintenance of main and auxiliary process equipment have been developed;
- normative sets of labour saving tools/means for the subteam and team work were developed and formed.

However, the repair organization identified the following deficiencies during the audit:

- insufficient level of qualification of line level engineering and technical workers (foremen) of repair services in the ability to organize the placement of workers in workplaces for equipment maintenance, to monitor the implementation of the shift task, and to make operational decisions when changing the shift task;
- insufficient level of qualification of maintenance personnel: workers have no notion of the required standard necessary to perform certain operations;
- insufficient level of production practices in the workplace.
The insufficient level of joint organization of engineering and technical workers in the field, namely:

- sending equipment to maintenance is not systematized by work schedules. The equipment is stopped by the customer service (technologists) to perform maintenance, based on the conditions of the manufacturing program for the production of finished products, which does not allow for high-quality preparation for maintenance and leads to loss of working time when shifting team workers to other production sites;
- there is no systematic approach to the preparation of equipment for maintenance (timely shutdown of equipment, preparation of assignment forms, etc.);
- increased loss of working time for registration of staff permits for work in existing electrical installations;
- in the approved model lists for maintenance of equipment there are items related to their repair, which in fact does not allow performing the entire scope of work specified in the assignment form (the standard only includes the labor costs for maintenance).
All of the above gave evidence of the need to jointly put in order the organization of planning and production of works on the maintenance of fixed assets of the customer [23–27].

From the graphs presented above, you can see that:

- the planned indicator of maintenance performance (in labor hours) is not synchronized with the possible training of personnel involved in the maintenance performance of both mechanical and processing and power equipment of the metallurgical corporate customer;
- in general, the dynamics of the actual personnel training follow the equipment shutdown schedule, while the actual working off exceeds the standard values. The main reasons for deviations are: not shutting down equipment for maintenance, long execution of permits, etc.

![Graph showing change in number of emergency stops during the year after taken measures.](image)

**Figure 3.** Change in the number of emergency stops during the year after the taken measures.

3. **Conclusion**

In order to improve the organization and performance of equipment maintenance, the customer and the contractor jointly implemented the following proposals:

- The explanations described above were taken into account when determining the methods for evaluating the maintenance performed for the joint approval of a unified methodology of applying the concept of a standard hour.
- The planning of performing equipment maintenance by day during the whole month was revised, which, in turn, allowed minimizing significant fluctuations in the scope of work and eliminating peak loads.
- The works on the maintenance of the mechanical and energy components of a single assembly were revised and combined as much as possible, which ensured the more efficient use of working time.
- The advanced training courses were organized for maintenance personnel performing maintenance of equipment.
- Work has been organized on updating the composition of the operations to be performed, since the scope of maintenance work in the assignment forms is not always representative of the complex of necessary operations.
- Preventive work with subordinate personnel is organized in the field of improving the industrial standards in the workplace.

Considering the positive dynamics of operational improvements in the organization and maintenance of equipment during the year, the reduction of emergency stops and the increase in equipment reliability, the measures taken were deemed appropriate and will be further implemented.

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