Management of Repair Service Structure of Industrial Enterprise When Transferring Repair Equipment for Outsourcing

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Abstract. In modern conditions, when the equipment of domestic industrial enterprises is significantly worn out, it becomes important to use outsourcing repairs as a way to improve the reliability of equipment by ensuring the quality of repair. The decision to outsource is made on the basis of different criteria using different approaches, some of which have certain drawbacks. For example, a decision based on a revenue change might be wrong because it is not related to outsourcing. Multi-criteria approaches are ineffective due to mutual compensation of deteriorating and improving criteria. The algorithm of decision-making on outsourcing of repair of the equipment and the choice of service providers on the basis of comparison of costs of outsourcing and insourcing is presented. The widespread structure of repair service of the industrial enterprises is considered and its reorganization in the conditions of repair outsourcing application is offered. The criteria and method of their calculation for the possibility of evaluating the effectiveness of repair outsourcing equipment. To assess the effectiveness of the reorganization of the repair service, the ratio of repair time, the number of failures, the number of defects, the repair costs are taken. For the detection of improvement or deterioration in the quality of the repair after the use of outsourcing, you must use the product of these relations.

1. Introduction
In conditions of greater wear and tear of the equipment of most domestic industrial enterprises, one of the ways to improve the reliability of the equipment by ensuring the quality of repair can be outsourcing. At the same time, many specialists pay attention to the expediency of developing the company's own maintenance service, noting its inherent strengths, noting its inherent strengths: efficiency, controllability, knowledge of the peculiarities of the equipment operation [1].

The development of our own repair services, departments may be associated with the concept of insourcing. The concept of insourcing is treated differently [2]. Insourcing is the expansion of the division's activities for additional utilization of existing capacities or assets. Insourcing can also be associated with the transfer of the project to an employee or department of the enterprise instead of transferring it to an external contractor [3-5]. However, it should be noted that the effectiveness of insourcing depends on the suppliers of parts, personnel and senior managers, which remain the same.

The decision-making mechanisms for outsourcing include the following approaches. A single-criteria approach is used for economic efficiency [2]:

$$E_{out} = \frac{H_{bo} - H_{ao}}{R} \times 100\%$$  \hspace{1cm} (1)

where $E_{out}$ – the cost-effectiveness of outsourcing, %;

$H_{bo}$ – the enterprise costs in the internal performance of the function before outsourcing, in monetary units (currency unit);

$H_{ao}$ – the enterprise costs after the implementation of outsourcing, currency unit;

$R$ – the enterprise revenue, currency unit.
The author I.L. Rudaya [6] notes the disadvantage of this approach is that the effect of outsourcing is calculated from changes in revenue, which may not be associated with the use of outsourcing.

In general, multi-criteria approaches can be expressed as follows [2]:

\[ E = \sum_{i=1}^{n} Wi(KAi - KBi), \]

where \( E \) – the outsourcing effect;
\( n \) – the criteria number;
\( Wi \) – the weight of criteria in the overall assessment;
\( KAi \) – the value of criteria after outsourcing;
\( KBi \) – the value of criteria before outsourcing.

The disadvantages of this approach may be due to the fact that the deterioration of some criteria can be offset by improving the values of others. As a result, the final value may indicate a positive effect, although the values of the most important criteria will be worse.

While repair outsourcing, in addition to saving by reducing the cost of the repair process equipment, it is also necessary to take into account the efficiency of equipment use.

2. Results
The evaluation of the criteria for the effectiveness of repair outsourcing should be carried out continuously. The analysis of the literature [7-9] have shown that the quality of services in repair of equipment may be determined by parameters such as:
- the repair time;
- the number of failures;
- the number of defects that reduce the performance of the equipment.

All three parameters should be kept to a minimum. To minimize the factors that have a negative impact on the use of repair outsourcing, it is also necessary to introduce new functions in the activities of the repair service of the enterprise – joint with the service provider preparation of the repair schedule, analysis of statistical information, analysis of the quality of services parameters.

2.1 Mechanism of decision-making on outsourcing
As a criterion reflecting the quality of the repair, you can take the availability parameter [2], which reflects all the losses at the stops (D), including any unplanned stops: equipment failures, stops due to a shortage of the raw materials or lack of storage space. To analyze the quality of repair, we will consider only the stops due to equipment failure. Consider the indicator - the planned production time:

\[ PPT = POT - PSD \]

where
- PPT – the planned production time;
- POT – the total operating time of the enterprise;
- PSD – the time of scheduled equipment stops for scheduled repairs and maintenance.

After you calculate the planned production time, you can determine the actual operating time for the past period:

\[ OT = PPT - D \]

where
- OT – determine the actual time loss time of the enterprise to stop,
- D – the equipment stop time due to failures.

The availability criterion is calculated according to the following dependence:

\[ A = \frac{OT}{PPT}, \]

where
- A – the criterion of equipment availability.

Thus, the equipment can be classified according to the availability criterion, using the Pareto principle, that is, for further analysis, choose 20% of the equipment with the lowest indicators of the availability criterion. For the selected equipment, it is necessary to consider the issue of transferring its repair to outsourcing. The first step is to select the equipment that is used in the main production, that is, directly in the manufacture of products. Next, it is necessary to analyze the causes of failures, and
leave under consideration the transfer of repair to outsourcing the equipment in which the causes of failures was low-quality repair.

Then, for each repair of the selected equipment, the possibility of outsourcing is considered, for this purpose, the possibility of performing repairs on the basis of the organization is estimated. But it should be borne in mind that the implementation of quality repairs on the basis of the organization is possible in the presence of competent personnel and equipment to obtain a quality result of the repair. In the absence of equipment, a comparison of the repair costs carried out by the organization, taking into account the cost of purchasing equipment and services of the outsourcing company.

If the purchase of new equipment costs the company more for a certain period than the outsourcing services, the efficiency of the process outsourcing is obvious. If the company does not have the necessary competencies to carry out repairs, then outsourcing the process can also be an effective solution.

If the decision to outsource is made, the calculation of equipment repair costs based on the use of outsourcing is calculated according to the formula:

\[ Cp = a + b + p \]  \hspace{1cm} (6)

where \( Cp \) – the costs associated with the repair of equipment under outsourcing, currency unit;
\( a \) – the costs associated with the wages of repair service employees, in terms of outsourcing, currency unit;
\( b \) – the cost of materials required for repair service to perform repairs, outsourcing, currency unit;
\( p \) – the costs for the services of the outsourcing company, currency unit.

The calculation of equipment repair costs on the basis of insourcing is calculated by the formula:

\[ Cp' = a' + b' + d \]  \hspace{1cm} (7)

where \( Cp' \) – the costs associated with the repair of equipment in the conditions of insourcing, currency unit;
\( a' \) – the costs associated with the wages of repair service employees, currency unit;
\( b' \) – the cost of materials necessary for the repair service to perform repairs, currency unit;
\( d \) – the depreciation of equipment, currency unit:

\[ d = \sum_{n=1}^{w} C_n \]  \hspace{1cm} (8)

where \( C_n \) – the amount of depreciation for n-equipment, currency unit;
\( w \) – the amount of purchased equipment.

The decision to outsource occurs when the following conditions are met:

\[ Cp' > Cp \]  \hspace{1cm} (9)

The algorithm of decision-making on equipment repair outsourcing can be described by the following block diagram (Figure 1):

**2.2 Service provider choice**

After deciding to outsource the repair and choosing the repair process that is outsourced, the next important issue is the choice of a service provider.

To do this, you need to answer the following questions:

- Does the supplier provide equipment repair services?
- Does the supplier carry out the type of repair that the organization has chosen to outsource?
- Does it carry out repair of equipment that the organization has chosen to outsource?
- Did the supplier carry out repair of the equipment unit, which the organization chose to outsource?

If the organization has chosen to outsource the repair of a particular model of equipment, it is preferable to have a supplier with experience with the same models of equipment. In the absence of suppliers with experience of repair of this model, it is necessary to choose suppliers offering as a whole current or capital repairs of the similar equipment.

If the organization is looking for vendor for repair of certain components, a preferable supplier having experience of repair of these sites. The mechanism for selecting service providers is shown in Figure 2.
Figure 1 – Algorithm of decision-making on equipment repair outsourcing

Figure 2 – Algorithm for the choice of service providers

2.3 Statistics of repair services in Omsk region
The formative evaluation of the proposals of the industrial service in the Omsk region (Table 1).
Table 1 – Enterprises – suppliers of industrial equipment repair services in the Omsk region

| Enterprise                                      | Location   | Type of service                                      |
|-------------------------------------------------|------------|------------------------------------------------------|
| The Federal state unitary enterprise «Omsk production Association «Itrysh» | Omsk       | Repair of metal-cutting equipment                     |
|                                                 |            | Inspection and preparation of equipment punch list   |
| ZAO«Omsk CTO AT»                                | Omsk       | Equipmentmodernization                               |
|                                                 |            | Overhaul of lathe groupmachine tools                  |
| OAO Factory «Trud»                              | Novosibirsk| Modernization and overhaul of machines                |

ZAO«Omsk CTO PO» also has an experience and the necessary equipment for repair of the following units of the equipment: devices of numerical program control NS-31, 2R22, 2842-65, MS2109, MS2105, MicroDAT, electric drives «Razmer 2M-5-21», «Razmer 2M-5-21\11», «KEMROS», «KEMTOK», «KEMRON», «KEMEK» and other similar drives.

And any experience with equipment:
- lathe machine 16B1TT1S1, 16K20F3, 16A20F3, 16K30F323, 16M30F3141, R755F341, 16D16AF1-01, F-11;
- milling machine AG-250, AG-400, NR5-38, MANO MN-500S, LF66, 6R13F3, WF-5N, GF2171S5, FP 7, SFP-13M;
- cutting machine SFP-1R;
- machining centers GDW-400, W400;
- coordinate boring machines IR2637PMF4, 24K40SF4, 2637GF1, 2620;
- heat cutting machine «Grant PPIKC-2.5»;
- grinding machine W3-205F3;
- hole-punching presses KO 126P, OCKO 126P;
- molding machine NR-5;
- galvanic line AG-44.

Thus, it is possible to choose suppliers on experience in repair with the certain model of the equipment, a type of repair (current, capital) or the node of the equipment.

2.4 Reorganization of repair service

In practice, the structure of the repair service includes the mechanical department, mechanical repair shops (MRS), shop mechanic service, equipment and material warehouses[7, 9-10].

The most widespread is the centralized organization of repairs, one of the main advantages of which is that the planning of repairs and its implementation are under one management. It increases reliability of performance of repair schedule and improves maneuverability of repair crews.

In connection with the use of outsourcing, the following changes in the organizational structure of the repair service are proposed: to create the department of statistics and management analysis, this structural change is due to the need to analyze the quality of repair in outsourcing conditions, for which it is necessary to maintain statistics on certain parameters. The department of repair management is created on the basis of the existing planning and schedule preventive bureau and schedule productive bureau with preservation of repair planning function on which load fell in connection with transfer of part of repair to outsourcing. To reduce the load of the chief mechanic in each unit, a Manager is appointed, whose functions are to analyze the incoming information and obtain solutions together with the chief mechanic.

Then the specialized teams are created according to the type of equipment, which includes specialists who are familiar with the relevant equipment of the enterprise. For example, several teams carry out repair of machines, other teams - the repair of particularly complex equipment and one team - the repair of crane equipment. The described recommendations are suitable for a mixed structure of repair service, which is the most common in industrial enterprises. The structure of the repair service after the proposed reorganization is shown in Fig. 3.
The criteria required to evaluate the effectiveness of equipment repair outsourcing were described above.

For the basic value of the repair time should be taken calculated value according to the standards. Then the time of repair performed by the outsourcer should not exceed the value according to the standards, or other values set by the enterprise.

To calculate the values of these criteria it is proposed to use the following relations:

\[ K1 = \frac{t_r}{t_s} \]
\[ K2 = \frac{n_{f1}}{n_{f2}} \]
\[ K3 = \frac{n_{d1}}{n_{d2}} \]

where \( t_r, t_s \) - the repair time before the reorganization, and according to standards;
\( n_{f1} \) - the number of failures before the reorganization of the repair service;
\( n_{f2} \) - the number of failures after the reorganization of the repair service;
\( n_{d1}, n_{d2} \) - the number of defects that reduce the equipment performance before and after the reorganization of the repair service.

The degree of economic efficiency can be estimated as follows:

\[ K4 = \frac{\mathcal{E}a}{\mathcal{E}p} \]

where \( \mathcal{E}a \) - actual repair costs while using equipment repair outsourcing;
\( \mathcal{E}p \) - planned indicator of repair costs when using equipment repair outsourcing.

At \( K4 \leq 1 \) it is possible to talk about the effectiveness of outsourcing. The process of using equipment repair outsourcing can be considered successful at the following values:

\[ K1 \leq 1, K2 \leq 1, K3 \leq 1 \text{ and } K4 \leq 1 \]

or with small deviations (5-10%).

For the detection of improvement or deterioration in the quality of the repair after the use of outsourcing, use following dependency:

\[ K = K1 \times K2 \times K3 \times K4 \]

3. Conclusion

The mechanism of decision-making on outsourcing of equipment repair on the basis of availability criterion and the mechanism of the choice of the supplier is offered. To improve the organization of repair service in the conditions of outsourcing, the criteria for evaluating the effectiveness of outsourcing equipment repair: repair time, the number of failures, the number of defects that reduce the performance of equipment; control of which will allow to make changes to the terms of the outsourcing contract. The presented dependencies can be used to detect improvement or deterioration of repair quality after outsourcing.
After the proposed reorganization, the structure of the repair service is proposed, in accordance with which it is advisable to create a department of statistics analysis, management and service teams specializing in the repair and maintenance of equipment of a certain type.

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