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PLANNING SOFTWARE ENGINEERING SPARE PARTS

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The method of planning and provision of spare parts in the operation of technical objects.

Reliability, planning, operation, performance, redundancy.

Successful problem solving to ensure the timely recovery technique is possible only if timely replacement units that are denied or resource produced during the operation.

To ensure the timely replacement of the warehouses at various levels created complex of spare parts (SP).

Nomenclature SP should reflect the character of typical failures that occur in the facility and meet the needs of their number, based on length of service and repair methods. In this regard, design object must comply shvydkoznimnosti and shvydkozaminnosti units. The various branches of engineering created specialized enterprise for manufacturing zch, and this production takes usually a significant part of the total production.

Planning of SP is a very difficult task.

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First, the setting range zch at the design stage or for a new car without the experience of its operation is not always possible. The lack of data on the rate of wear and durability, lack of information about the operation of the prototype, or similar products, inaccurate methods of calculating length of service – all this leads to the fact that the designer has the ability to establish a list of parts that wear out quickly, with only a rough approximation.

Second, in determining the needs SP the entire period of operation of the machine is not always known all spectra anticipated operational loads and conditions and repairing cars.

Number SP required when operating fleet can be assessed in two main ways:

- based on statistical data from the field of operation of prototypes, which gives enough precise picture only stable in relation constructive models of cars and constant analysis of trends in demand SP;

- calculation methods combined with statistical modeling.

Maintenance and repair of equipment required, on the one hand, decentralization spare parts, on the other – support for warehouse inventory levels ekspluatatsiyinyh business units not below reasonable standards, providing the necessary readiness. Thus, the importance SP determined the need for preparedness techniques and the ability to reduce economic costs during its operation.

The aim – to develop methods of planning and provision of spare parts in the operation of technical objects.

Materials and methods research. The problem solved by providing a challenging layered system of interconnected units and different functions. The model system of SP companies in which the operation of machinery may be submitted in the form mnohorivnevoyi, hierarchical system with a simple subordination S .

- When tuning of the ability to understand the system software to meet the needs of operating companies (OC), which provide facilities engineering spare parts. Often used as performance indicators are:

- allowable downtime supply facilities in inoperable due to lack of spare parts;

- the value of complete reliability indicators in the form factor of operational or technical coefficient using technology and others.

The main requirement to put quality evaluation engage in solving the problem of risk $F\left(Q,Q^*\right)$, which is determined by the ratio between the actual Q and planned Q^* requirements for parts. The criterion for optimality system software can be represented as a minimum expectation of average risk [2]

$$M\left[F\left(Q,Q^*\right)\right]=min.$$

The exact form of this criterion can be determined if the set fine for deficit $P(q)$ dissatisfaction with demand q items and supplies fine $h(q)$ for the preservation of the planning period q units remaining after satisfaction of all orders. The function of the middle line has the form [1]:

$$F(x+z)=\begin{cases}\int_0^{x+z} h(x+z-\nu)\gamma(\nu)+\int_{x+z}^{\infty}(\nu-x-z)\gamma(\nu)d\nu, \text{at } x+z>0\\ \int_0^{\infty}P(\nu-x-z)d\nu, \text{ at } x+z\le 0,\end{cases} \cdot(1)$$

where x – the number of parts stored in a warehouse since the beginning of the planning period; z – the number of parts that come to the warehouse for the planning period; $\gamma(\nu)$ – probability density function ν orders SP.

The impact on the system of SP availability factor of objects that served characterizes the average downtime objects repaired due to lack SP

The main indicator for assessing the effectiveness of the provision is likely that downtime N facilities through the provision of the interval T will be:

$$P_0(T)=P\left(\tau=0/N,T\right)\quad\left(\tau=0/N,T\right). \qquad (2)$$

Methods of planning strongly depends on the structure of the system. Consider the case where the system software components are only at the sites of the lower level, ie each OC. In the top-level body S_0 No part of it provides only the functions of planning and management.

Delivery parts the warehouse OC carried out at the beginning of the planning period T. The problem is reduced to the formation of an order for the required number of parts and supply of spare parts from the parent organization or from industry to warehouses OC at the beginning of the planning period. Recovery comes to replacement item (object), which he refused, the new that is received from the warehouse. Therefore, the model OC will be filed with chain N solitary connected to the same "workers" elements of the safety function $P(t)$. These elements are in operating condition, and their possible failure are independent.

In accordance with OC composition seems as K such items that are in storage mode. Each of these elements can instantly replace any of the workers in case of failure. Failure of this system is only if the lost stock, and then refused one of the work items that meet system failure $K+1$ and more failures items. Must adjusting stock K, ensure probability of occurrence is not over K failures of the planning period T no more than a given $P_з$:

$$P(T) \geq P_з .$$

It is easy to see that this problem is similar to the problem of assessment of the reliability function unloaded sliding reserve. To obtain its solution is sufficient to specify the function of reliability $P(T)$ and will consider its exponential in the interval planning T:

$$P(T) = exp(-\lambda t),$$

where λ – failure rate.

$$P(t) = exp(-N\lambda t)\sum_{i=0}^{N}\frac{(N\lambda t)^i}{i!}. \qquad (3)$$

Therefore, the condition of reliability assurance system has the form

$$P(t) = exp(-N\lambda t)\sum_{i=0}^{N}\frac{(N\lambda t)^i}{i!} \geq P_з(T),$$

where $P(t)$ – probability of providing spare parts for the range T; $P_з(T)$ – acceptable probability level security, which is defined by a higher authority.

To determine the minimum number of parts after transformations we obtain

$$\sum_{i=0}^{K}\frac{(N\lambda t)^i}{i!} \geq P_з / exp(-N\lambda t). \qquad (4)$$

Substituting the values $i = 0,1,2,...,$ find a $i = K^*$, where equation (4) is met for the first time. value K^* means the optimum number of parts that need to be put to the OC for the planned period.

For example, you must determine the number of spare elements to probability $P(t)$ system and one spare elements of failure $\lambda = 0,5$ 1/ hour. was equal 0,95 at $t = 8$ hour.

Decision. determine $a = N\lambda t = 1 \cdot 0,5 \cdot 8 = 4$. From the Table column. 8 [3], which corresponds $a = 4$, summarize all probability, since last as long as the amount does not reach $1 - 0,95 = 0,05$.

Get:

$0,0001 + 0,0002 + 0,0006 + 0,0019 + 0,053 + 0,0132 = 0,0213 < 0,05.$

So choose the number of spare parts $N = 6$. At $N = 7$ summation gives the number more than $0,05$.

You can also plan a number of other means SP the planning period under the following conditions: $N = 50$ – the number of objects in the number of objects in OC;

$P_з = 0,9$ – given allowable probability of support;

$T = 13000$ год. – напрацювання ОС, встановлене на плановий період.

This failure rate of this type SP the previous period of operation will be: $\lambda = 1,03 \cdot 10^{-4}$ 1/год.

Decision. Determine the value of a variable a:

$$a = N\lambda t = 50 \cdot 1,03 \cdot 10^{-4} \cdot 13000 = 66,95 = 67.$$

In this case we have the expression:

$$\sum_{i=0}^{K} \cdot \frac{67^i}{i!} = \frac{0,9}{exp(-67)}.$$

Substituting the left side of the expression values $i = 0,1,2,...,$ get a $i = K$, where the equation is satisfied. As a result, we obtain the value $K = 78$.

For the case when the object is composed of the same elements, reliability function described by:

$$P_0(t) = exp\ \ -r\lambda t\ \ ,$$

and the probability of OC, including N facilities are operated and K spare parts, expression

$$P(t) = exp\ -Nr\lambda T\ \sum_{i=0}^{K} \frac{(Nr\lambda t)^i}{i!}. \quad (5)$$

If planning is carried out for multiple parts OC_m, $\overline{m} = \overline{1, M}$ when given for each enterprise software requirements for probability $P_{зm}, \overline{m} = \overline{1, M}$, then the minimum number K_m^* spare parts for concrete OC_m should be determined by the expression

$$exp(-N_m \lambda T) \sum_{i!}^{K_m} \frac{(N_m \lambda t)^i}{i!} \geq P_{зm}.$$

If the sum K_m^* for all the EP, we find the right amount of spare parts for all OC_m, $\overline{m} = \overline{1, M}$ the planned period of delivery of spare parts

$$K_m^* = \sum_{m=1}^{M} K_m^*$$

Where no local storage for each OC, supply of spare parts to replace items that were denied, made directly from a single central warehouse, located on the second level. In this case, we can assume that all M united in a common enterprise venture with the number of work items

$$N_\Sigma = \sum_{m=1}^{M} N_m.$$

For the joint OC minimally acceptable level of probability of software can be defined by the expression:

$$P_{\partial\Sigma} = \frac{\sum_{m=1}^{M} N_m P_{зm}}{\sum_{m=1}^{M} N_m}, \quad (6)$$

where $P_{зm}$ – given the likelihood software m-th company, $m = \overline{1, M}$.

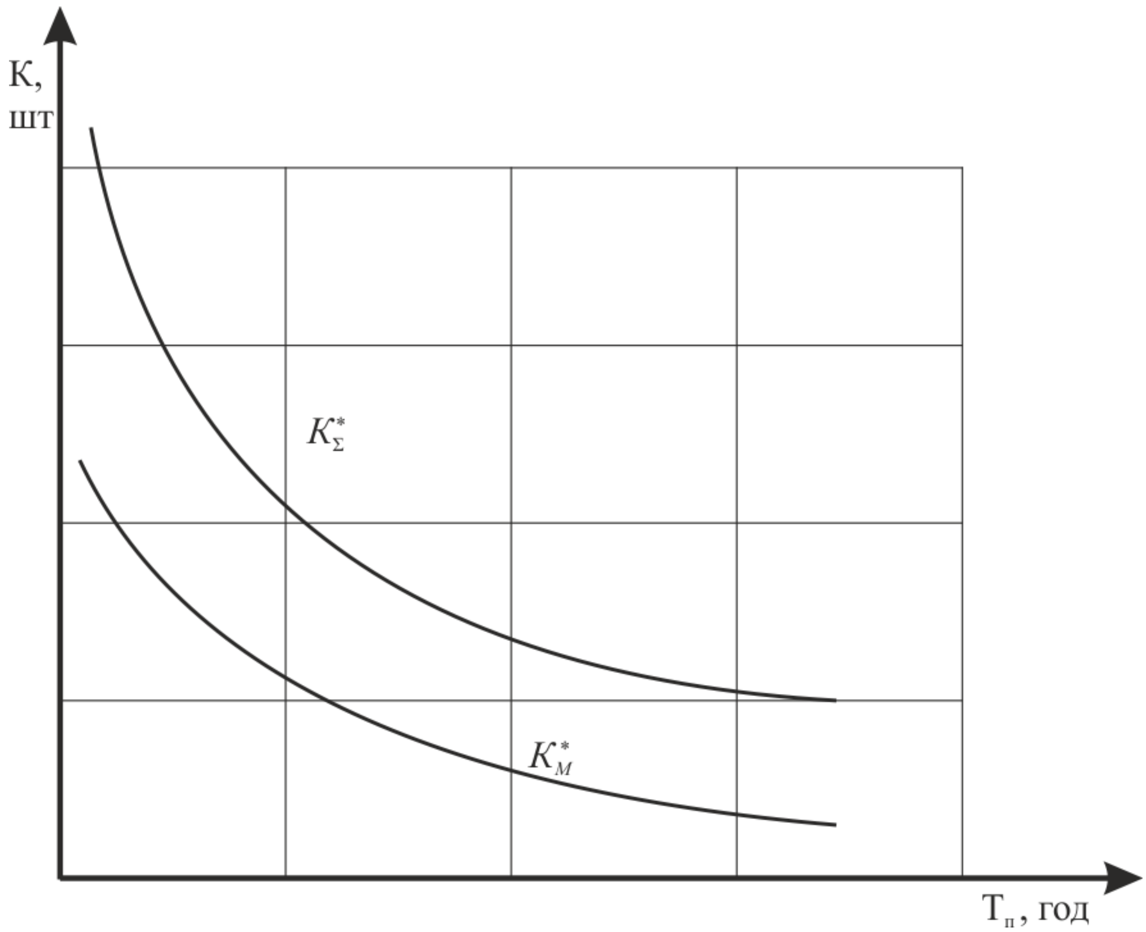
Qualitative comparison of the two strategies above (Figure) can be made based on similar models in question with models theory reservation.

In this case, the transition to the second (the central warehouse) support structures is identical to zoom in (multiplicity) booking booking unloaded sliding. Therefore, the relation

$$K_M = \sum_{i=1}^{M} K_m^* \succ K_\Sigma^*,$$

where K_Σ^* – the number of parts required for the combined OC.

Analysis of the dependence shows that the system software from a central warehouse that provides significant savings to the number of required parts, and the savings increases significantly with increasing requirements on the probability of support.



Dependence of the number of parts downtime $T_п$.

In the case of supply depots lower level necessary to provide a single maximum in terms of supply to all OC at all planning period. Therefore, the cost of purchase of spare parts in this case are the maximum and transportation - minimal.

In the case of direct supply from the central part of the cost of purchase of spare parts is minimalnnymy, but greatly increases transportation costs.

The process of such calculations are very time consuming. To simplify the procedure of calculation used pre-designed tables or nomograms. In addition, using a simplified method for determining the number of parts in which the average rate of the cost of spare parts for each object in the year (8760 hrs.) Determined by the formula:

$$n_{зср} = \frac{8760\,K_в}{t_{р\,ср}}.$$

where $K_в$ – utilization of the objec; $t_{р\,ср}$ – average resource unit.

Usually the total scheduled operating time during the year t_Σ.

Then

$$n_{зср} = \frac{t_\Sigma}{t_{р\,ср}}.$$

To maintain the reliability of the number of parts depending on the service life changing and can be determined by empirical formula [4]:

$$n_{зт} = \frac{n_{зср}N}{C}(1-e^{-Bm}),$$

where m – current year operation of the facility, $m = 1,2,3,...$; C – factor reducing repair cycle the object, $c = 0,8...0,9$; B – empirical value, which depends on $n_{зср}$.

For $n_{зср} = 0,005...0,095$: $B = 76,315 n_{зср}^{3,29}$;

For $n_{зср} = 0,096...1,0$: $B = 0,38 n_{зср}^{1,038}$.

Results.

Example 1. Determine the number of parts for first ($m=1$)and third ($m=3$)years of operation $N = 40$ objects in $n_{зср} = 0,5$; $C = 0,8$.

Decision. For the first year of operation:

$$n_{з1} = \frac{0,5 \cdot 40}{0,8}(1 - e^{-0,38 \cdot 0,5^{-1,038} \cdot 1}) = 4,2.$$

Enacting $n_{з1} = 5.$

For the third year of operation:

$$n_{з3} = \frac{0,5 \cdot 40}{0,8}(1 - e^{-0,38 \cdot 0,5^{-1,038} \cdot 3}) = 10,65 \approx 11.$$

Example 2. Determine the minimum number Z_{min} parts in stock-return valves, for which the rate of spending 100 hours. of objects $N_e = 0,05.$ Planned developments year $T = 3500$ hours., time of delivery of the middle warehouses $\tau = 5$ days, the number of nomenclatures $M = 200,$ warehouse inventory availability factor $K = 0,8.$

Decision. Determine the average cost of hangers per year:

$$a = 0,01 N_e T = 0,01 \cdot 0,05 \cdot 3500 = 1,75 \approx 2 \text{ units / year.}$$

With a special table at $a = 2$ і $\tau = 5$ для $K = 0,8$ define $Z_{min} = 1.$

Thus, using the strategy of providing a central warehouse appropriate only for important objects that are expensive and objects, which rarely occur refusal when transport costs fully offset savings for the purchase of spare parts.

Conclusions

Use the following methods to determine the required number of parts, which should cause downtime avoid possible technical facilities due to lack of spare parts. Thus, we solve the problem providing a fixed level of technical readiness of objects and minimizing the cost of their operation.

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Разработана методика планирования и обеспечения запасными частями при эксплуатации технических объектов.

Надежность, планирование, эксплуатация, показатели эффективности, резервирование.

Developed a method of planning and provision of spare parts in the operation of technical facilities.

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