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OPTIMIZING THE WORKING CAPITAL OF SPARE PARTS IN AUTO SERVICE ENTERPRISES

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Abstract. This article discusses the theoretical foundations of solving the problem of optimizing the volume of the working capital of spare parts and determining options for organizing the logistics support system (LSS) at car service enterprises.
Keywords: technical service, car repair, car service services, coefficient of technical readiness, vehicles, technical operation system, spare parts, working capital, optimization, logistics, coefficient of planned use, components, parts, reliability, reliability, safety, nomenclature of spare parts, single stock, group stock, inventory management system.

In modern regulatory documents for automobile service enterprises, the "Technical Readiness Coefficient" indicator is introduced. It characterizes the readiness level of the "vehicle – technical operation system" complex in optimal condition and accounts for all types of downtimes. These include planned maintenance, unscheduled maintenance, and waiting for the necessary spare parts. The Technical Readiness Coefficient can be determined using the following formula:

$$K_{TK} = K_{EQRF} \cdot K_{CHTT} \cdot K_{MTTTT}$$

Where: K_{EQRF} - represents the planned usage coefficient of spare parts;
K_{CHTT} - denotes the readiness coefficient of the vehicle in an unlimited material-technical supply system;
K_{MTTTT} - stands for the readiness coefficient of the material-technical supply system (LSS).

The planned usage coefficient of spare parts reflects the share of time a vehicle is not required to undergo scheduled maintenance.

One of the key conditions for ensuring a certain readiness level of vehicle components and systems is maintaining an optimal size of the working capital of spare parts. It is crucial to identify the relationship between the achieved readiness coefficient (in this case, K_{MTTT}) and the inventory size, i.e., the value of its spare parts.

Initial Data Required for Calculating the Readiness Coefficient of the LSS System:

- Information about the composition of vehicles;
- Data on the reliability of the structural components of vehicles (failure intensity);
- Average time required for delivering or repairing components;
- Initial data for each type of spare part;

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Information on inventory management strategy models.

The theoretical basis for optimizing inventory volumes is detailed in the literature. This includes issues related to calculating the readiness coefficient of the LSS system. The readiness coefficient K_{MTTTT} of the LSS system is computed as the sum of the readiness coefficients for each type of part:

$$K_{TT} = \sum_{i=1}^{M} K_{M_{MTTTTi}}$$

Where: M - is the number of spare part categories;
K_{MTTTTi} - is the readiness coefficient of the LSS system for the i -type of part or system (i = 1,...,M).

The formula for evaluating K_{MTTTTi} depends on the inventory management model adopted for spare parts or systems for that i- type of vehicle. The key parameter of any inventory management model is the initial stock volume:

$$A_{bosh.\text{-rejasiz}} = (A_1,\ldots,A_M)$$

Here, A_i - represents the initial quantity of the i- type (i = 1,...,M) of part or system. Common LSS System Organization Scenarios:

- **Single Stock (O):** Spare parts or systems are stored in a single location near the automobile service enterprise to ensure quick delivery or replacement.
- **Group Stock (G):** Multiple types of spare parts or systems are maintained in nearby automobile service enterprises or regionally distributed facilities, ensuring optimal delivery times for all components.
- **Two-Tier Inventory Management System (2D):** This system includes individual stocks at the first (lower) tier and replenishable group stocks at the second (upper) tier sourced from external suppliers.
- **Multi-Level Inventory Management System (KD):** An extension of the two-tier system where different replenishment strategies are employed, such as:
- **Periodic Replenishment Strategy:** Stocks are replenished at predefined intervals to the initial level.
- **Emergency Delivery with Periodic Replenishment Strategy:** Stocks are replenished periodically with emergency deliveries in exceptional cases.
- **Continuous Replenishment Strategy:** Orders are placed immediately after any stock depletion.
- **Threshold-Based Replenishment Strategy:** Orders are triggered when the stock level of a particular type falls below a predefined threshold.

The group inventory system is examined in detail using a mixed replenishment strategy:
Periodic replenishment for non-repairable parts;
Continuous replenishment for repairable parts. This model, with some variations, is widely employed in most automobile service enterprises.

Continuous Replenishment Model

This model assumes that if a component or system installed in a vehicle fails, the replacement is done using spare parts from the working capital. Subsequently, an immediate order is placed to replenish the stock.

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The continuous replenishment model is commonly used for repairable parts, where service organizations can quickly repair defective parts and return them to operational condition within a certain average repair time. This ensures that the readiness coefficient of the material-technical supply system (K_{MTTTi}) for the i- type of part or system can be evaluated using the formula:

$$K_{MTTTi} = 1 - \frac{(m_i \cdot \lambda_i \cdot T_i)^{A_i+1}}{(A_i+1)! \cdot \sum_{j=1}^{A_i+1} \frac{(m_i \cdot \lambda_i \cdot T)}{j!}}$$

Where: m_i - represents the number of operational parts or systems of the i-th type;
λ_i - is the failure rate of the i-th type of part or system expressed in calendar time;
T_i is the average time from the moment of order creation to delivery, including average repair or delivery time.
This approach enables enterprises to maintain an optimal readiness level while ensuring cost-effective inventory management.
A_i - is the initial stock of the i-th type of part or system.

Periodic Replenishment Model

This model assumes that inventory is replenished at regular intervals. In such a case, the replenishment occurs until the initial stock level (A_i) is reached.

This model is used when automobile service enterprises are located in distant areas, and the transportation of spare parts is carried out at specified intervals.
For this model, the formula for calculating K_{MTTTi} is:

$$K_{MTTTi} = \frac{1}{m_i \cdot \lambda_i \cdot T} \sum_{j=0}^{A_i} (1 - \sum_{k=0}^{j} \frac{(m_i \cdot \lambda_i \cdot T_i)^k}{k!} \cdot e^{-m_i \cdot \lambda_i \cdot T_i}),$$

Where T_i - is the periodic replenishment time for parts and systems.

Use of Replenishment Strategies to Ensure Readiness. The methods for evaluating readiness in this model can also be applied to calculate the initial stock quantity required to meet readiness (reverse task). The initial stock of spare parts is denoted as $A_{boshl.\text{-}rej\text{-}magan} = (A_1, \ldots, A_M)$ for parts of types 1 to M.

Assuming that the technical readiness coefficient must be at least **μ**, the condition for the inventory's readiness coefficient can be expressed as:

$$K_{ЭГ} \approx K \ \cdot K_{ГБС} \cdot K_{ГМТОi}(A_{нач-непл}) \geq \mu$$

If the planned use coefficient K_{EQRF} and the readiness coefficient in an infinite supply system K_{CHHT} are known, this condition can be written as:

$$K_{MTTTTi}(A_{bosh.-reja-magan}) \geq \frac{\mu}{K_{EQRF} \cdot K_{CHHT}} = \gamma$$

Thus, an initial inventory needs to be formed to ensure the readiness coefficient of the LSS system does not fall below **μ** a specific value.

This problem has an infinite number of possible solutions, as the required readiness level can be achieved by infinitely many combinations of large inventory volumes. An additional condition is that the initial inventory must be purchased at the minimum price. Therefore, the optimized initial inventory volume can be calculated as:

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$$\sum_{i=1}^{V} A_i \cdot C_i \to \min \; ; \; K_{MTTTTi}(A_{boshl-rej-magan}) \geq \gamma,$$

Where C_i -is the cost of the i- type of part or system.

Steps to Solve Using Coordinated Descent:

Step 0: Set the initial vector of parameters $A^{(0)}_{boshl-rej-magan}$, with the initial stock of all part types set to zero. $A^{(0)}_{boshl-rej-magan)} = (0,...0)$ K_{MTTTT} ($A^{(0)}_{boshl-rej-magan}$,)

Step i+1: In step i+1 $A^{(i)(+j)}_{boshl-rej-magan}$, examine vectors obtained by increasing stock for the j-th part type. The number of such vectors equals the number of part types M.

For each j-type, calculate values and determine the vector that maximizes the change in the readiness coefficient:

$$\Delta N_j = \frac{\ln K_{MTTTTi}(A^{(i)(+j)}_{boshl.-rej-magan} - \ln K_{MTTTTi}(A^{(i)}_{boshl.-rej-magan}}{C},$$

After checking the conditions $A^{(i+1)}_{boshl.-rejeejema} \geq \gamma$, if they are met, the algorithm terminates. Otherwise, proceed to step i+2.

Conclusion

In conclusion, it can be inferred that to ensure the readiness coefficient of the MTT system is not lower than the required value, an initial inventory needs to be formed with the minimal purchasing cost.

References:

1. ГОСТ 27.002-89 Reliability in Technology. Basic Concepts, Terms, and Definitions.
2. Cherkesov, G.N. "Assessment of System Reliability Considering Spare Parts", St. Petersburg: BHV-Petersburg, 2012.
3. Shura-Bura, A.E., Topolsky, M.V. "Methods of Organizing, Calculating, and Optimizing Spare Parts Sets for Complex Systems". Moscow: Znanie, 1981.
4. Sharipov, K.A., Polvonov, A., Abdusattorov, N. "Theoretical Aspects of Territorial Location Modeling of Automobile Service Enterprises." The Seybold Report ISSN 1533-9211.
5. Sudov, E.V., Levin, A.I., Petrov, A.N., Petrov, A.V., Borozdin, D.N. "Analysis of Logistics Support. Theory and Practice", Moscow: Inform-Buro Publishing, 2014.
6. ГОСТ Р 53392-2009. Integrated Logistics Support. Analysis of Logistics Support, Moscow: Standartinform, 2010.
7. Polvonov A.S., Abdusattorov N.A. "Ways to Improve Car Service Enterprises." Global Symposium on Humanity and Scientific Advancements, Jacksonville, Florida, USA, May 30th 2022.
8. Polvonov A., Abdusattorov N. "Problems of Restoring the Beds of Main Bearings and Studying the Deformation-Strength Properties of Polyurethane Adhesives." International Journal of Early Childhood Special Education (Int-JECSE), doi:10.9756/intjecse/v14i7.50.