EXAMINING THE PARAMETERS OF A SYSTEM FOR SUPPLYING SPARE PARTS WITH CONTINUOUS STOCK FILLING

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Abstract: *The structure of the system for supplying spare parts for tractors and self-propelled agricultural equipment has been examined. A centralized system of continuous inventory replenishment has been investigated and the influence of the basic parameters of the supply system on the probabilities of refusal of execution of requests is determined.*

It has been shown that the most significant impact on performance indicators of the spare parts supply system is the demand flow intensity.

The mass inflow of highly productive and expensive machinery in agriculture, on one hand, and climate change, requiring a reduction in the timeframe for the implementation of major technological operations in crops, on the other hand, led to an increase in machine load and loss during their standown. The annual load of universal tractors with a capacity of 80 to 110 hp. Has reached 700-800 motor hours, and those with more than 150 hp. exceeded 1,200 hours. This imposes new stricter requirements on the structure and organization of activities to maintain the working ability of self-propelled agricultural machinery. Its main element is the supply and distribution of spare parts (aggregates, assemblies, parts) and consumables.

Machine manufacturers build a system to supply equipment owners to ensure timely delivery of spare parts and consumables. A pyramidal sourcing system is normally applied, i. The agricultural producers' warehouses (farms, agricultural organizations) are loaded from regional warehouses, from the official importer for the country and from the central warehouse of the company-producer.

A pyramidal supply system is a hierarchical model where several lower-level warehouses are attached to a warehouse from a higher hierarchical level, and they serve a group of warehouses at the lowest level. The following basic features are inherent in such a system:

- Impact of the stock level on a higher hierarchical level on the ability to meet demand at lower levels;
- total costs depend not only on the total stock but also on its distribution among the components of the end-user supply system with spare parts and consumables.

Reviewing a centralized system for supplying consumers with homogeneous items (aggregates, assemblies, details) and consumables made up of a replenishment source (warehouse of the company-producer) of the stock and a two-tier network of warehouses - central (warehouse of the official representative of a producer for the country), To which are attached several regional, directly serving users under the following assumptions:

A) the flow of orders entering into any regional warehouse is a simple stream of flux with known parameters [1,2];

B) after an element of the regional warehouse is sold, an order for filling of the warehouse with another element of the central warehouse is filed;

(C) after the central warehouse element is taken, a request shall be made and it shall be filled in by the charging source;

D) if the stock level in the regional warehouse is zero, the reserve element is taken from the central warehouse and the order from the regional warehouse ceases to be waiting in the queue;

(E) if the level of stock at the central warehouse is zero, the consumer shall be supplied with a spare charging source element and the request to the central warehouse shall cease to exist.

Based on these assumptions, and using the Mass Warehouse Theory, we can deduce dependencies to determine the average wait time for the supply of a spare element - T, [3,4]

To formalize the task, we enter the following characters:

n - Is the number of regional warehouses;

λ_i - The flow rate of the user requests from the *i*-th regional warehouse, $i=1, \dots, n$;

h_i - Average delivery time of the user item from *i-th* regional warehouse, *h*;

t_i - The average delivery time of the element in the *i*-th regional warehouse from the central warehouse, *h*;

θ - The average delivery time of the element in the central stock from the source to fill the stock, *h*;

x_i - the initial level of the stock of elements in the i-th regional warehouse, number.;

y - The initial level of the stock of elements in the central warehouse, number.

В съответствие с направените допускания:

- the central warehouse is a y-linear mass service system with losses with a simple incoming flow and a parameter $\lambda = \sum_{i=1}^{n} \lambda_i$ And average service time θ. Then, according to the mass service theory [3,4], the probability of refusal to request a reserve element from the central warehouse is $P(y) = \frac{1}{y!} r^y \Big/ \sum_{k=0}^{y} \frac{1}{k!} r^k$, where $r=\lambda.\theta$.
- *i-th* regionanal warehouse x_i - Linear mass service system with losses with a simple input stream, parameter λ_i and average service time $\theta_i = t_i + P(y)\theta$.

Then the probability of refusal to execute a request from the i-th regional warehouse is

$$P(y, x_i) = \frac{1}{x_i!} \rho_i^{x_i} \Big/ \sum_{k=0}^{x_i} \frac{1}{k!} \rho_i^k \text{, където } \rho_i = \lambda_i \theta_i .$$

Thus, the average wait waiting period to serve the user request for a reserve element brought to the *i-th* regional warehouse will be:

$$H(y, x_i) = h_i + P(y, x_i)\left[t_i + P(y)\theta\right].$$

For the time T in the *i-th* regional warehouse are submitted on average $\lambda_i T$ Requests, and the total wait time for users will be average

$$T_{общ} = \sum_{i=1}^{n} \lambda_i T H(y, x_i) .$$

The main parameters of the system are: the probability of refusal to execute a request from the central warehouse $P(y)$; average delivery time for a spare item in the central warehouse θ From source of element feed; Probability of refusal to execute an application from the i-th regional warehouse $P(y,x_i)$; Average duration of execution of the request for a backup element of the user who has applied to the *i-th* regional warehouse $H(y,x_i)$; Total wait time for user for specified period $T_{общ}$.

When changing the intensity of requests for spare elements coming from the i-th regional warehouse, the change in the basic parameters $P(y)$, θ_i, $P(y, x_i)$ and $T_{общ}$ it is shown in Figure 1. the graph shows that the change is more significant $P(y)$ and $P(y, x_i)$ when increasing λ_i, $T_{общ}$ varies proportionally to the query intensity, while the average time for delivery of the element to the central stock from the source to fill the stock (θ_i)Is almost a constant value up to $\lambda_i < 1.0h^{-1}$.

On figures 2÷4 the graphical dependencies of the basic parameters of the supply system are given depending on the delivery time t_i, The initial level of the stock of elements in the i-th regional warehouse x_i, the average delivery time of the i-th warehouse user item h_i, The average delivery time of items in the central warehouse from the source of stock replenishment θ and the initial stock in the central warehouse *y.* From the analysis we find that some of the system parameters are not interconnected, for example on $P(y)$ only affects θ and *y,* and the other parameters h_i, t_i, do not affect it at all. Here we find that the most important and complex is the influence of query intensity λ_i over $P(y, x_i)$, θ_i, $P(y)$ and $T_{общ}$.

By modifying the number of regional warehouses *n* functionally connected to the central warehouse, it reduces the probability of refusal to execute an application from the *i-th* regional warehouse $P(y, x_i)$ fugure 5. and figure 6.

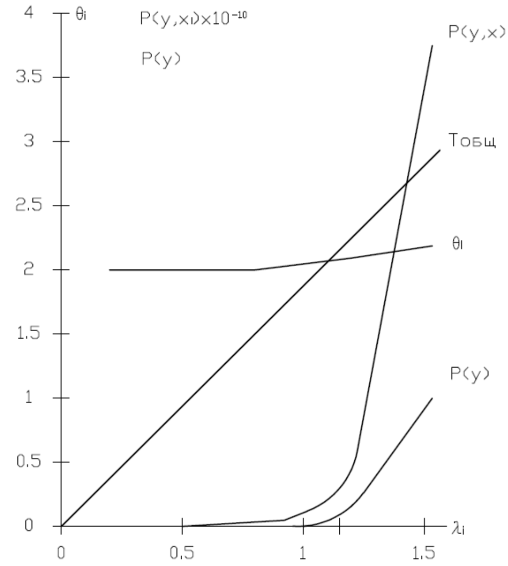

Fig.1. Character of change of the basic parameters of the system for supply with continuous filling of the stocks in function of the flow intensity of the requests λ_i : P(y) - The probability of cancellation of the order from the central warehouse; $P(y,x_i)$ - The probability of refusal to execute a request from the i-th regional warehouse; θ_i - Average request service time; $T_{общ}$ - Total wait time for users.

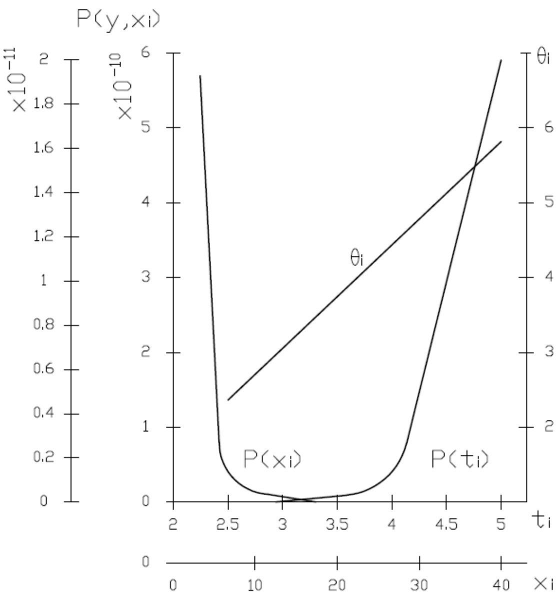

Fig. 2. Modification of the probability of refusal of request from the central warehouse $P(y,x_i)$ and average service time θ_i depending on the average delivery time of the item in the i-th regional warehouse from the central warehouse t_i and the initial Stock level x_i in it.

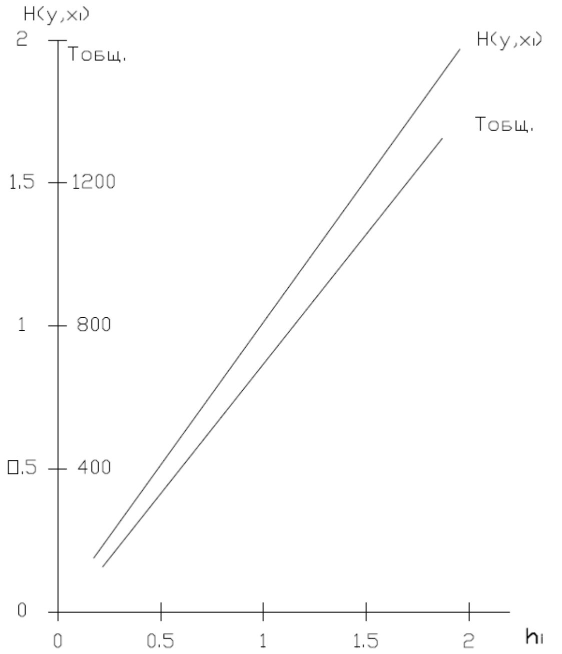

Fig. 3. Changes in the user's average request time for requesting spare parts $H(y,x_i)$ and the total wait time of the user $T_{общ}$ in dependence on the average time of supply of the user element From the i-th regional warehouse

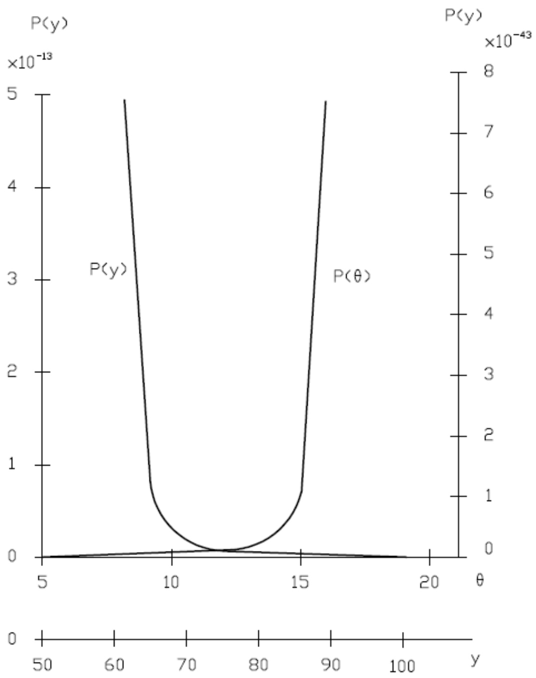

Fig.4. Change of the probability of refusal of a reserve item request from the central warehouse P(y) depending on the average time of arrival of the element in the central stock from the charging source θ and the initial level of the stock of elements in the central warehouse (y)

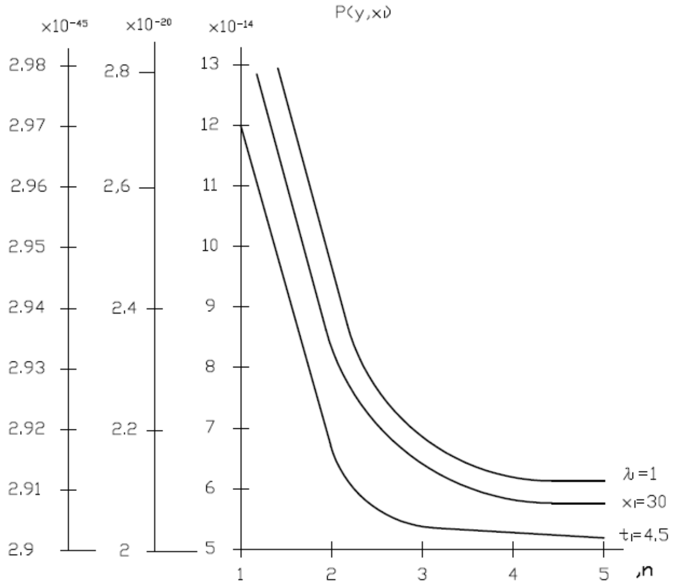

Figure 5. Changing the probability of refusal of an order from the i-th regional warehouse P(y,x_i) depending on the number of regional warehouses (n) with: $\lambda_i = const$ *;* t_i*=const;* x_i*=const.*

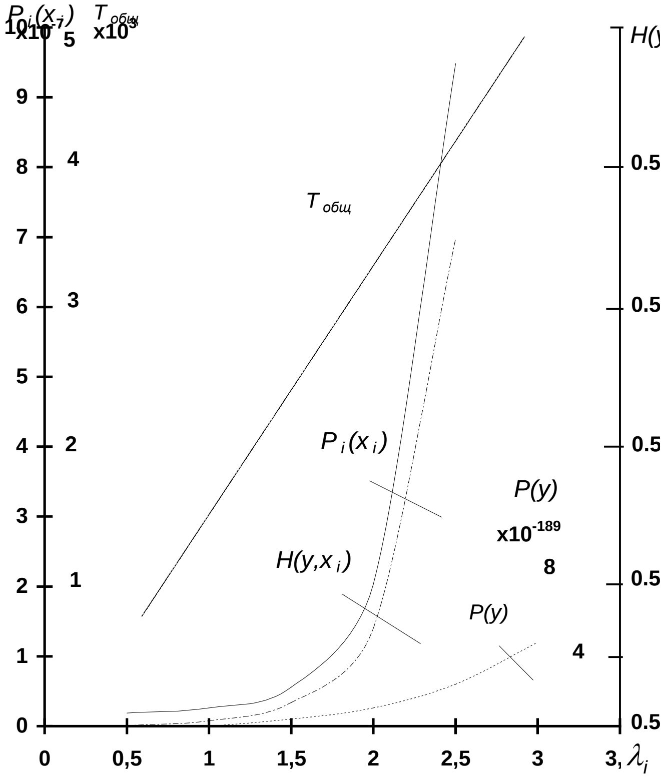

Fig.6. The nature of the change in the probability of executing an application from the central warehouse P(y), the probability of fulfilling an application from the i-th regional warehouse P (x_i), the time of delivery of the items to the consumer H (y, x_i) And the total wait time for users $T_{общ}$, depending on the flow rate of the queries λ_i

Conclusions:

1. The impact of basic parameters(λ_i, x_i, t_i, θ, y n) has been investigated of the supply system with continuous filling of stocks with spare elements on the probabilities of refusal to execute the requests from the i-th regional warehouse $P_i(x_i)$ and from central warehouse *P(y).*

2. It has been proven that the most significant impact on the performance indicators of the spare parts supply system is the demand flow intensity λ_j and losses due to waiting for spare items α.

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