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**«Research on losses of technical preparedness of forage harvesters  
combines by level of seasonal service accumulation»**

Authors:

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# Problem statement

- In modern countries, there is such a price policy of agricultural machinery, spare parts for it, and despite the fall in prices for black gold, the prices of fuel and lubricants that agricultural producers, realizing the obtained products, are not able to fully update outdated machines for new ones, which leads to even more aging of the park and increasing the cost of maintaining it. In general, the average load on combine for 2019 was 285 hectares or 822 tons (with a yield of 3.03), and considering the technical condition (79% of serviceable ones) [3], respectively, 358 hectares or 1035 tons. Maintenance of forage harvesters is performed by the maintenance service. In order for this service to function effectively, it is necessary to optimize the number of the main system-forming objects, which include maintenance units, gas stations and field repair machines.



# Solution methods

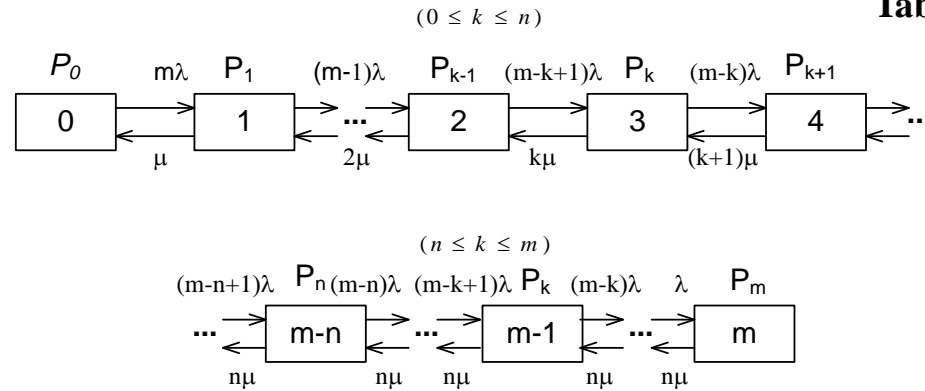


Figure 1. Graph of possible states of single-channel queuing system for elimination of failures of forage harvesters

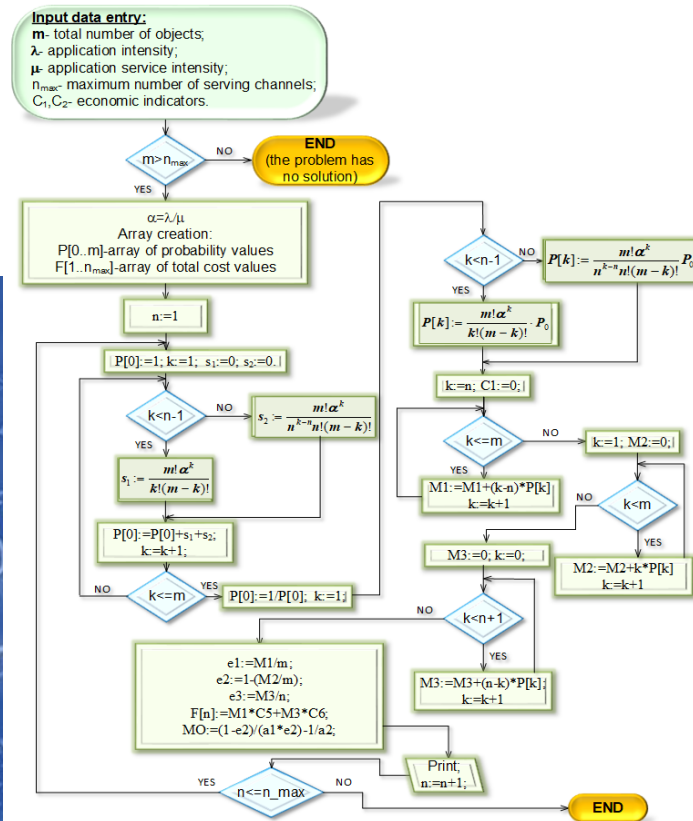


Table 1. Density of flow of requirements and intensity of service by years of operation and annual operating time

| Years of operation of combines | Quantity, units | Annual operating hours, ha (intervals and midpoints) |                |                |                |                |                   | 1/hour |
|--------------------------------|-----------------|--|----------------|----------------|----------------|----------------|-------------------|--------|
|                                |                 | 150-180<br>165                                       | 470-500<br>485 | 630-660<br>645 | 780-810<br>795 | 840-870<br>855 | 1000-1030<br>1015 |        |
| 1 year                         | 3               | 0.218  | 0.179          | 0.181          | 0.175          | 0.179          | 0.157             | 0.612  |
|                                | 5               | 0.364  | 0.298          | 0.3025         | 0.291          | 0.298          | 0.262             |        |
|                                | 10              | 0.727  | 0.596          | 0.604          | 0.582          | 0.596          | 0.524             |        |
|                                | 15              | 1.091  | 0.894          | 0.906          | 0.873          | 0.894          | 0.785             |        |
|                                | 20              | 1.454  | 1.193          | 1.208          | 1.164          | 1.193          | 1.047             |        |
| 2 year                         | 3               | 0.455  | 0.373          | 0.378          | 0.364          | 0.373          | 0.327             | 0.3138 |
|                                | 5               | 0.757  | 0.621          | 0.629          | 0.606          | 0.621          | 0.545             |        |
|                                | 10              | 1.515  | 1.242          | 1.259          | 1.212          | 1.242          | 1.090             |        |
|                                | 15              | 2.273  | 1.864          | 1.889          | 1.818          | 1.864          | 1.636             |        |
|                                | 20              | 3.03   | 2.485          | 2.518          | 2.424          | 2.484          | 2.182             |        |
| 3 year                         | 3               | 0.4  | 0.328          | 0.332          | 0.32           | 0.328          | 0.288             | 0.4    |
|                                | 5               | 0.667  | 0.547          | 0.554          | 0.533          | 0.547          | 0.48              |        |
|                                | 10              | 1.333  | 1.093          | 1.108          | 1.066          | 1.093          | 0.96              |        |
|                                | 15              | 2  | 1.64           | 1.662          | 1.6            | 1.64           | 1.44              |        |
|                                | 20              | 2.667  | 2.187          | 2.216          | 2.133          | 2.187          | 1.92              |        |
| 4 year                         | 3               | 0.291  | 0.238          | 0.242          | 0.233          | 0.238          | 0.209             | 0.4464 |
|                                | 5               | 0.484  | 0.397          | 0.402          | 0.387          | 0.397          | 0.349             |        |
|                                | 10              | 0.969  | 0.795          | 0.805          | 0.775          | 0.795          | 0.698             |        |
|                                | 15              | 1.454  | 1.192          | 1.208          | 1.163          | 1.192          | 1.047             |        |
|                                | 20              | 1.939  | 1.590          | 1.611          | 1.551          | 1.590          | 1.396             |        |
| 5 year                         | 3               | 0.236  | 0.193          | 0.196          | 0.189          | 0.193          | 0.170             | 0.4256 |
|                                | 5               | 0.393  | 0.323          | 0.327          | 0.315          | 0.323          | 0.283             |        |
|                                | 10              | 0.787  | 0.646          | 0.654          | 0.630          | 0.646          | 0.567             |        |
|                                | 15              | 1.181  | 0.969          | 0.982          | 0.945          | 0.969          | 0.850             |        |
|                                | 20              | 1.575  | 1.292          | 1.309          | 1.260          | 1.292          | 1.134             |        |
| 6 year                         | 3               | 0.227  | 0.186          | 0.188          | 0.181          | 0.186          | 0.163             | 0.46   |
|                                | 5               | 0.378  | 0.310          | 0.314          | 0.303          | 0.310          | 0.272             |        |
|                                | 10              | 0.757  | 0.621          | 0.629          | 0.606          | 0.621          | 0.545             |        |
|                                | 15              | 1.136  | 0.931          | 0.944          | 0.909          | 0.931          | 0.818             |        |
|                                | 20              | 1.515  | 1.242          | 1.259          | 1.212          | 1.242          | 1.090             |        |
| 7 year                         | 3               | 0.2  | 0.164          | 0.166          | 0.16           | 0.164          | 0.144             | 0.4488 |
|                                | 5               | 0.333  | 0.273          | 0.277          | 0.266          | 0.273          | 0.24              |        |
|                                | 10              | 0.666  | 0.546          | 0.554          | 0.533          | 0.546          | 0.48              |        |
|                                | 15              | 1  | 0.82           | 0.831          | 0.8            | 0.82           | 0.72              |        |
|                                | 20              | 1.333  | 1.093          | 1.108          | 1.066          | 1.093          | 0.96              |        |

# Conclusions

## Results, implementation

- The total costs are insignificant depending on the year of operation of the combines and their annual loading. These costs are reduced accordingly from 13.63% to 3.12%. The number of these combines in the group has more impact on the amount of costs.
- Formation of suboptimal number of servicing links gives loss of funds from 3187 to 1881 UAH (1 and 7 years of operation). For the harvest period, growers should involve additional service professionals for the required optimal number of units, which will allow to offset additional losses and reduce the cost, including the cost of grain quality, due to the timing of the harvest.

# Contacts

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