OPTIMIZATION OF THE NUMBER OF HARVESTING AND TRANSPORT COMPLEXES IN WHEAT FARMING

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Abstract: The efficient operation of the harvesting transport complex (grain harvester - transport aggregate) depends on the organization of the transport service and the identification of the necessary means of transport is a probable task.

An economically viable ratio counts combines, service vehicles for which minimizes the target function:

\[ S = C_1 \lambda t_{ov} + C_a n \Rightarrow \min \]

Overview of pre-selection - transport complex as a mass service system.

When machines are operating in a group, service requests are continually being carried out on a grain harrow filled grain hopper and after unloading the hopper, the combine is restarted and is a potential source of new orders.

Thus, the "harvester-car" system is considered a mass service system in which a service request per unit time arises on average.

We assume that the stream of queries is a simple (Poisson) stream that is ordinarily, stationary, and without consequences.

The query flow intensity is \( \lambda \), and the bandwidth of the service channel is \( \mu \). Then the average number of grain combinations waiting to be served by transport means \( m_s \):

\[ m_s = \left( \frac{\psi^{n+1}}{n!n\left(1 - \frac{\psi}{n}\right)^2} \right) \times \left( \sum_{k=0}^{n} \frac{\psi^k}{k!} + \frac{\psi^{n+1}}{n!(n - \psi)} \right)^{-1}. \]

Where \( \Psi = \lambda t_{ov} \), and \( t_{ov} \) is the average wait time for service start requests.

The mathematical model for optimizing the number of vehicles for servicing a group of grain harvesting combines is:

\[ S = C_1 m_s + C_2 n_z \Rightarrow \min \]

\( C_1 \) is the value of the layover time of the combine harvesters, \( C_2 \) - the value of the vehicle’s layover, \( n_z \) - the average number vehicles, waiting to be loaded from the combine harvester.

The proposed model is certified with real data for agricultural cooperative in Yambol and the results show that for 5 CLAAS combine harvesters, is optimally served by three cars working in a group.

KEYWORDS: COMBINE HARVESTERS, SERVING CARS, REQUESTS, MASS SERVICE SYSTEM, MATHEMATICAL MODEL, OPTIMIZATION.

The efficient operation of the harvesting transport complex (grain harvester - transport aggregate) depends on the organization of the transport service and the identification of the necessary transport means is a probability task.

The aim of the study is to propose a mathematical model for optimizing the number of harvesting-transport complex in wheat growing and to approbate it into the practice.

An economically viable ratio counts combines and vehicles servicing them, in order to minimize the target function:

\[ S = C_1 \lambda t_{ov} + C_a n \Rightarrow \min \]

Where \( C_1 \) are losses per hour stay of harvesters in a state of waiting for service, BGN; \( \lambda \) - Average number of filled bunkers (service requests) for 1 hour; \( t_{ov} \) - the average wait time of each service request, h; \( C_a \) - The hourly loss of a vehicle maintenance (sum of the mid-term evaluation, the value of the renovation allowances and the wages of the driver, BGN / h; \( n \) - The number of cars in the retractable - transport complex.

We consider a harvesting- transport complex as a system of mass service [1,2,5,6] (fig.1).
When machines are operating in a group, service requests on a grain-filled grain hopper are continually being carried out and, after unloading the hopper, the combine is again started and is a potential source of new orders. Thus, the “harvester-car” system is seen as a mass service system in which in average arises a service request $\lambda$ per unit time.

At the same time, each vehicle (service channel) is able to meet a request $\mu$ per unit of time.

We assume that the flow of requests is a simple (Poissonian) flow that is ordinarily, stationary and without consequences [3,4].

The flow rate of requests is $\lambda$, and the throughput of the service channel is $\mu$. Then the average number of grain combines waiting to be served by means of transport $m_s$ [1,2]:

$$m_s = \frac{\psi^{n+1}}{n!n \left(1 - \frac{\psi}{n}\right)^2} - \sum_{k=0}^{n} \frac{\psi^k}{k!} + \frac{\psi^{n+1}}{n!(n-\psi)}$$

Where $\Psi = \lambda t_{obs} - \mu t_{obs}$ is the average wait time for service start requests.

The number of standby vehicles is determined by the dependence:

$$n_z = n - \Psi$$

The proposed model is certified with real data for agricultural cooperative in Yambol.

**Table 4.13 Output information to optimize the number of harvesting transport complex in wheat growing**

<table>
<thead>
<tr>
<th>n</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>$m_s$</td>
<td>12,889</td>
<td>0.866</td>
<td>0.448</td>
<td>0.302</td>
<td>0.228</td>
<td>0.183</td>
<td>0.153</td>
<td>0.131</td>
<td>0.115</td>
<td>0.102</td>
</tr>
<tr>
<td>$n_z$</td>
<td>0.072</td>
<td>1.072</td>
<td>2.072</td>
<td>3.072</td>
<td>4.072</td>
<td>5.072</td>
<td>6.072</td>
<td>7.072</td>
<td>8.072</td>
<td>9.072</td>
</tr>
<tr>
<td>$S$</td>
<td>2579,578</td>
<td>199,934</td>
<td>141,375</td>
<td>137,217</td>
<td>147,380</td>
<td>163,393</td>
<td>182,367</td>
<td>203,044</td>
<td>224,793</td>
<td>247,259</td>
</tr>
</tbody>
</table>

In Fig. 2 there is a graph of the function describing the relationship $S = f (n)$, where $S$ is the loss of downtime of the operating machines, and $n$ is their number. An inflection point of the resulting curve is defined, describing the dependence $S = f (n)$ by a first derivative.
Conclusions:
1. The cereal harvesting process and grain transportation is formalized as a model of a mass service system.
2. A mathematical model has been proposed for optimizing the number of vehicles used for the operation of the grain harvesters in a group.
3. The results for the 5 CLAAS grain harvesters working in a group in the Yambol region are optimally served by three vehicles with a certain load capacity.

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