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Research of Operations in the Production Strategy of Mini-Lines for the Grain Processing of Cereal Crops

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Abstract: The study proposes a substantiation of producing mini-lines (food equipment) on a typological row of productivity on the example of agricultural machinery of the Republic of Kazakhstan.

Key words: Grain, mini-line, typological series, productivity, Mechanical Engineering, example

INTRODUCTION

A significant place for processing grain in grits in Kazakhstan is taken by small enterprises and farms which for the last 4 years is 68-75% of the total volume of its production. Although, with the growth of the country's economy, the use of medium-sized and more powerful enterprises becomes more effective, the importance of small enterprises in this sector of agriculture is still considerable and it is no accident that its account for 80% of the total number of enterprises engaged in processing of rice, buckwheat and oats.

The researches show (Konstantinov *et al*., 2013) that all processing enterprises of rice, buckwheat and oats in Kazakhstan are divided into three groups depending on productivity, 0.1-0, 5, 0.5-2.0, 2.0-5.0 t/h. The first group consists of small enterprises and farms which today have about 15 types of mini-lines with productivity 0.1-0.5 t/h. These small enterprises as far as their economic possibilities were concerned, bought these lines abroad or collected them in parts from the food equipment produced in the country.

The current steady growth of the economy of the Republic of Kazakhstan makes it possible to create the material and technical base of agricultural machinery for the production of its own mini-lines for processing of rice, buckwheat and oats, thus, satisfying demand of small enterprises and farms.

MATERIALS AND METHODS

When collecting and analyzing the materials for the article were used statistical data. In a substantiation to produce mini-lines for processing grain of rice, buckwheat and oats were applied methods of operations research (Taha, 2007; Rao, 2009; Intriligator, 2012; Schoenherr *et al*., 2012; Ventzel, 2013; Crainic and Semet, 2013; Donkova, 2017).

Making a decision to develop and produce its own mini-lines for processing grain of rice, buckwheat and oats, agricultural machinery will have to face a problem, the essence of which is as follows.

With the existing large number of types of operating food equipment, arises the question whether to create lines of the same productivity (of the same type) that could provide the processing of any volume of grain from the available in practice, two types, one of which could meet the needs of any farm, district or region and another with a lower productivity more simple and cheaper in production and operation or several types each of which could meet the needs of certain farms.

At the same time with the increasing number of line types, the expenses on development, testing and production are increased (several types need to be developed in place of one type), the specific cost of each type of line increases due to a decrease in the output of each type of line and finally, increase expenses per using each type of line.

Obviously, there are a definitive number of types (series) of lines and definitive performance each of them, under which total expenses are minimized.

Having statistical data, it is possible to obtain the integral F(q) or differential φ(q) function of the line distribution by powers which can be considered a function of the demand from the performance argument as well as the simple expense functions of production lines $C_0(q)$, development expenses, testing and setting for the production of a new type of $C_p(q)$ lines and the expense

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on operating the equipment per unit time of $C_e(q)$ from the same argument. Practice shows that in many cases these dependencies can have a linear form that is, $C_0(q) = a{\cdot}q$, $F(q) = b{\cdot}q$, $C_p(q) = c{\cdot}q$, $C_e(q) = m{\cdot}q$.

It is required to determine the definitive number of line types as well as the values of the performance at which the total expenses are minimized.

Let N be number of types of lines with performance $q_1, q_2, ..., q_n$ and each line of the k-th type is applied in the range of capacities from q_k-1 to q_k.

Then, we can write the following term for the total expenses S_N, neglecting the output of the lines as they operate:

$$S_N = \sum_{k=0}^{N} \left[F(q_{k+1})\text{-}F(q_k)\right]\times C_0\ (q_{k+1})+\sum_{k=0}^{N} C_p(q_{k+1})+ \int_0^T \sum_{k=0}^{N} C_?(q_{k+1})\left[F(q_{k+1})\text{-}F(q_k)\right]dt \quad (1)$$

where, T is the operating time. When solving the main task of researching, the best solution is one that ensures the fulfillment of the task at minimum material expenses.

Taking into account that complete lines for processing grain of rice, buckwheat and oats in Kazakhstan are not produced yet, we used data on the expense of manufacturing its in Russia (Anonymous, 2016a, b), translated into the national currency.

RESULTS AND DISCUSSION

As a result was obtained an empirical dependence $C_0(q) = a{\cdot}q = 12\ q$ (Fig. 1). Using statistical data was obtained well approximated linear integrated demand excosecant, having the form $F(q) = 205\ (q\text{-}0.1)$ (Fig. 1).

Determining the expenses on development and production involves some difficulties and is the task of economic science and forecasting.

We take the level of expenses on development that comparable to the level of expenses on production and exceed it three to four times, giving an interval evaluation of the results.

We solve the problem in general form, taking $F(q)\leq 0$ for $q\leq q_0$ and $F(q) = b(q_N\text{-}q_0)$ for $q>q_N$. Not taking into account the expense on operation in the functional 1, the solution of the problem is as follows. We define the number of types of lines, choose the optimal values of the arguments for this case by normal methods and calculate the expenses. Repeating this procedure for a different number of types, we select the optimal number of types.

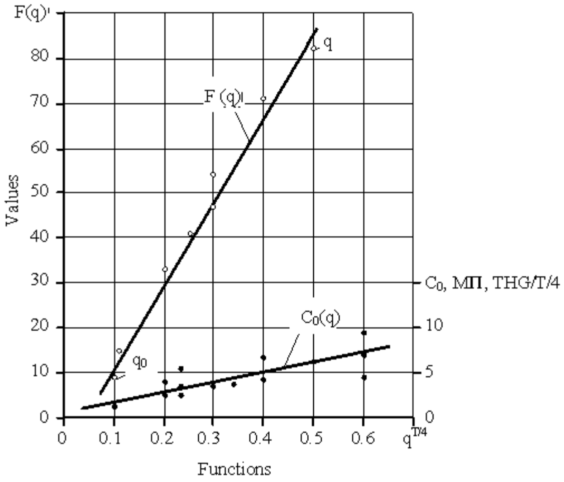

Fig. 1: The integral function of the demand F(q) and the production expense function $C_0(q)$ of the lines for processing of rice, buckwheat and oats grain

If the line type is one that is, N = 1, then it is obvious that the value of the argument must be qN and the total expenses in this case are calculated by Eq. 2:

$$S_N = b(q_N\text{-}q_0)\times aq_N + cq_N \quad (2)$$

We write this equation in a non-dimensional form:

$$\tilde{S}_N = \frac{S_N}{a\times b\times q_N{}^2} = 1\text{-}\tilde{q}_0 + k \quad (3)$$

Where:

$$k = \frac{c}{a\times b\times q_N},\ \tilde{q}_0 = \frac{q_0}{q_N}$$

If there are two types of lines that is N = 2, then the performance of lines of the first type is determined from the cost minimization condition and for the second type it is still q_N. In this case, the relative total expenses are:

$$\tilde{S}_1 = \tilde{q}_1(\tilde{q}_1\text{-}\tilde{q}_0)+1\text{-}\tilde{q}_1+k\tilde{q}_1+k \quad (4)$$

Equating the first derivative of S 1-0 and solving the resulting equation, we have:

$$\tilde{q}_{1\,onm} = \frac{1+\tilde{q}_0\text{-}k}{2} \quad (5)$$

The optimal total expenses for this case will be calculated by the equation:

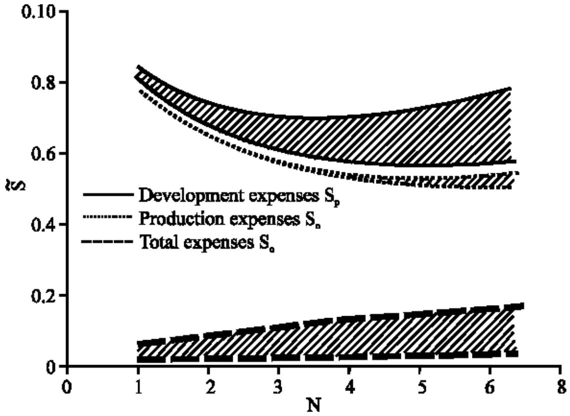

Fig. 2: Dependence of total expense S on the number of types of lines N for processing buckwheat, rice and oat grains

$$\tilde{S}_{1?nm} = \frac{3-2\tilde{q}_0-\tilde{q}_0{}^2+k}{4}+\frac{3+\tilde{q}_0-k^2}{2}\times k \qquad (6)$$

The first item is the expense of production S 1p, the second is the expense of developing S 1p. The problem is solved similarly in those cases when the number of line types is three or more.

The results of calculations with development expense commensurate with the expenses of production (c≈a) and exceeding them four times (with ≈4a) are shown in Fig. 2.

Let us trace the nature of the change in the relative expenses of development and production as well as the total expenses, depending on N.

The relative expenses for the production of lines decrease monotonically with increasing N and the development expenses increased almost linearly with increasing N. The total relative expenses for a very shallow curve are reduced to N = 6, while at N = 4, 5, 6 they are little distinguishable. With N = 4, the optimal series of productivities will be 0.340-0.385, 0.540-0.580, 0.705-0.785 and 1. With a loss of not more than 3.5% and in the presence of additional considerations in favor of reducing the number of types, can be adopted a range of three types of lines with the optimal range of productivities being 0.437-0.457, 0,703-0,723 and 1 and the optimal ranges of productivities in natural units (t/h) will have the form when developing three types of lines 0.21-0.23, 0.34-0.36, 0.5 when developing four types of lines 0.17-0.19, 0.27-0.29, 0.35-0.39, 0.5.

As can be seen thst the increase in development expenses in the considered range did not significantly affect the optimal performance values (in the development of the three types of lines, the difference is not more than 9.5% and in the development of four types-not more than 11.4%).

CONCLUSION

The results show that optimizing the production of mini-lines based on a typical performance series can bring up to 27% decreases of the development and production expenses in the circumstances under consideration.

A specified costs estimate on developing, production and cost accounting of operating mini-lines for processing grain of rice, buckwheat and oats will allow obtaining a more accurate optimal range of their productivity, adopt this range as standard and standardize it for the conditions of agricultural engineering in Kazakhstan. A similar approach can be used when mini-lines are bought abroad.

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