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Adaptive system of parameter settings of self-moving harvesters – threshers' operational procedures.

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ABSTRACT

This article sets out the principle of automatic control of the operational procedures' parameters of a serial harvester – thresher in response to changing soil fertility parameters, based on the developed algorithm and program, using statistical data on the results of the harvesters' check-outs.
Keywords: self-moving harvester – thresher, adaptive (self-organizing) system, parameter settings, soil fertility parameters, operational procedures.

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INTRODUCTION

It was believed that at the turn of the 80-s a certain limit of a capacity, production, thresh quality and grain loss was reached in the development of harvester – threshers with a classical scheme of its' threshing and separating device. It was believed that the main design parameters ($X_к$) to ensure these indicators had reached their size limits on the length and diameter of the threshing drum, the length of the straw, the sieve cleaning area, weight, dimensions, etc. Therefore, they began to pay more attention to the creation of new organisms and models in order to increase the efficiency of the harvesters – threshers' operational procedures [1-4, 11].

The harvesters' updating sometimes led to an increase in the number of devices installed in the vehicle cab. In these circumstances, it was difficult for the machine operator to ensure manually the harvester's optimal operational regime under the ever-changing individual parameters of the soil fertility (Z), such as grain yield, lie-down and weed infestation, grain and straw humidity, etc.

One of the area of creation of new working organisms is the implementation of electronic devices on the basis of on-board computers for optimal control of the harvester's moving in the field and automatic control of dynamic parameter settings (X), such as the harvester's speed, rotation velocity of the threshing drum and separator fan, clearance setting of deflector blades opening, tape-transport mechanisms, etc., in accordance with the changes of the current soil fertility Z [5, 12]. It acts to raise the effectiveness of the harvester's operational procedures (Y), where the effectiveness is understood as a maximum capacity under the loss and shattering of grain restrictions, or as a minimum grain loss under the production and shattering of grain restrictions due to technical issues.

RESULTS AND DISCUSSION

In the present context it is technically impractical to install a large number of devices in the harvester's cab. For obtaining of summary data on the harvester's work, it is quite possible to process original information, using an on-board computer and applying electronic sensors of internal parameters control of settings X and external parameters of soil fertility Z.

The national self-moving harvesters – threshers do not have on-board computers able to provide automatically the harvesters' parameter setting X for the optimal operation Y, in accordance with the changing parameters of the soil fertility Z. In this regard, they lose out to the foreign harvesters of the same class in the competition on a global scale.

The creation of algorithms, programs, an element base for the automatic control of parameter settings X of the harvesters – threshers and an element base for the control of the soil fertility parameters Z in order to provide more effective operation procedures of the harvesters Y is the main aim and tasks facing the national science.

One of the promising areas of harvesters – threshers' automation is a monitoring and control system of a maximum loading of the threshing mechanism of harvesters in order to increase their productivity. The parameter settings system should ensure the sustaining uniformity of the grain bulk flow and stabilize the release of grain from a straw mass, which maximizes the effective use of the modern harvesters – threshers. In this case, the monitoring system should control the load on the threshing mechanism, and the system of sustained grain flow should support this load by the automatically change of parameter settings of the harvester. The transmission of signals between the monitoring and control systems provides the possibility to perform complex agricultural and technical practices of a quality which cannot be achieved with a traditional (mechanical) manual control. Therefore, it can be effective a digital technology which transmits a large amount of information covering: accessory and harvesters' systems drives, information, adjustments, control, diagnostics, operation results accumulation, decisions to change the operating modes, data transmission from the sensors to the on-board computer, satellite positioning systems of the harvester in the field, communication systems between the on-board computer and the PC located in an office of computer center (supervisory authority) [6, 13].

Now, if the operational procedures of a self-moving harvester – thresher is represented as the following model

$$Y = F(X, Z), \qquad (1)$$

where Y is a vector of output parameters (productivity and capacity, grain loss and shattering, impurity, reliability, etc.); X is a vector of parameter settings of a harvester (harvester's running speed, rotation velocity of the threshing drum and separator fun, clearance setting of deflector blades opening, output and input gap setting of the threshing drum, harvester's operating width, etc.), ($X \subset G_x$); a vector of area-based soil fertility parameters (grain yield, cultivation lie-down, grain and straw humidity, weed infestation, grain to straw correlation, etc.); ($Z \subset G_z$); $G = \{G_x U G_z\}$ is a state space where the harvester's model is operated, which corresponds to a certain area, cultivation and type of gathering, and the vector of structural parameters (length and diameter of the threshing drum, length of straw-walker, area of sieves, weight, dimensions, etc.) is constant for the given harvester's model (X_K = const), the adaptive system of operation of a self-moving harvester – thresher can be represented as the following block schematic diagram (Figure 1).

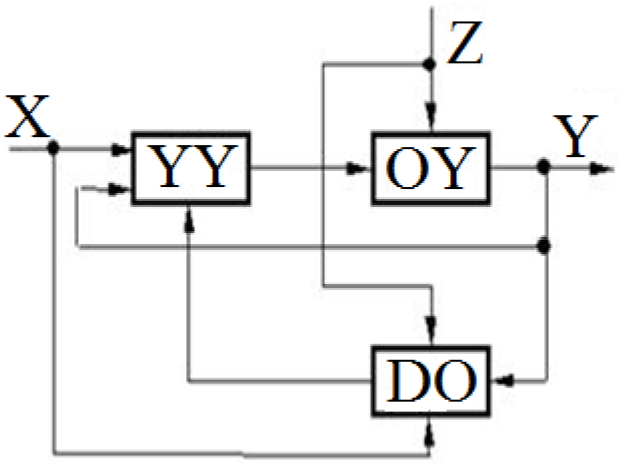

Figure 1: Adaptive control system block schematic diagram

where YY – actuation device, OY – controlled element, DO – drift recorder.

If we solve the problem of optimal programming according to the model (1) with respect to the parameter settings [5, 6, 14]:

find x *,
with a condition of max (min): $y = f(x_i\ z_j)$, (2)
under the following restrictions:

$$g(x_i, z_j) > 0,\ x_i \subset G_x,\ I = 1, n,\ z_j \subset G_z,\ j = 1,m, \qquad (3)$$

where x_i are optimization parameters; z_j = controlled soil fertility parameters, which can change within a certain limits during the harvester's operation in a determined field; G_x and G_z are confidence intervals, we can provide, for example, a maximum harvester's productivity under the loss and shattering of grain restrictions (or minimum loss under production and shattering of grain restrictions).

We propose a parameter settings automatic control system for the harvesters – threshers, based on discrete statistical data following the test results and harvesters' operation under the conditions of real exploitation, which volume allows to create a large database to develop an algorithm and a motion control program with the optimal setting of the operational procedures for the effective work (maximum productivity under the loss and shattering of grain restrictions).

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We can see in the figure a fragment of maintaining of an optimal productivity of the harvester – thresher "Don-1500B" thanks to the speed adjustment according to the changing yield and grain humidity during the harvest gathering procedures. The optimization task (2), (3) is solved using the algorithm [7, 9].

The technical result is achieved by means of adjustment of the operating organisms of a self-moving harvester – thresher, characterized by introducing into the on-board computer of general discrete statistical information accumulated according to the test results of the similar samples of the self-moving harvesters – threshers, subject to the following parameters: harvester operation effectiveness Y (W, q_m, q_a, C, D, T), where W is grain productivity, q_m – threshing machine loss, q_a – adapter loss, C – value of impurity in the hopper, D – value of shattering of grain, T – specific fuel consumption; of the soil fertility Z (Y, B_3, B_c, Z, P, CH), where Y is a grain harvest, B_3 – grain humidity, B_c – straw humidity, Z – weed infestation, P – haulm stand lie-down, CH – blind-seed disease; the harvester's settings X (V, n_b, n_o, s_e, s_a, s_o, s_u), where V is the harvester's running speed. n_b – number of revolutions of the threshing drum, n_o – number of revolutions of the separator fun, s_e – clearance on entering the threshing mechanism, s_a – clearance at the outlet of the threshing mechanism, s_o – value of the chaffer fin opening, s_u – value of seed screen deflector blades opening. On the basis of this information a mathematical model should be created Y (W, q_m, q_a, C, D, T) = f { Z (Y, B_3, B_c, Z, P, CH), X (V, n_b, n_o, s_e, s_a, s_o, s_u)), which provides the operational procedures implementation according to the parameters (W, q_m, q_a, C, D, T), the parameter settings should be calculated (V, n_b, n_o, s_e, s_a, s_o, s_u), solving the optimization problem using one of the effectiveness indicators, with soil fertility parameters restrictions (Y, B_1, B_c, Z, P, CH) and settings restrictions (V, n_b, n_o, s_e, s_a, s_o, s_u); then according to the results of the current harvester's operation, the new discrete statistical information Y_i, Z_i, X_i is obtained, with the subsequent restructuring of the mathematical model Yi = f(Z_i, X_i) and the calculation of new parameter settings on its' basis (V, n_b, n_o, s_e, s_a, s_o, s_u)$_i$, by the solving of the optimization problem using one of the effectiveness indicators, at every turn, at specific time intervals [8, 10].

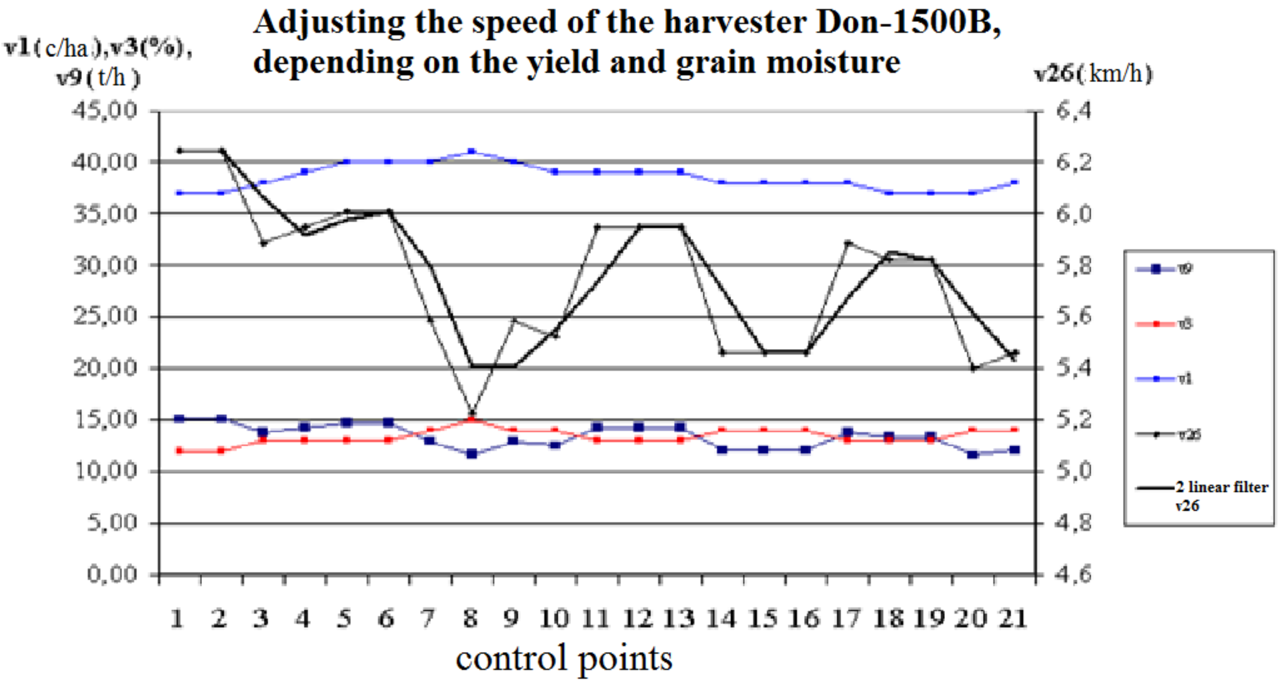

Figure 2: Operation principle of the control system of the harvester «Don-1500B» based on the speed

CONCLUSION

The self-moving harvesters – threshers have all conditions for the installation of electrical and (or) hydraulic drives according to all internal parameter settings X (revolutions of the threshing drum, revolutions of the separator fun, amount of output and input clearance of the threshing machine, value of the chaffer fin opening and seed screen deflector blades opening, etc., as well as the harvester's motion speed regulation).

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The only problem resides in the development and creation of sensors to install on the harvester, with a subsequent control of the changing soil fertility parameters and the loss value of the harvester.

GRATITUDE

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