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AN APPROACH FOR DESIGN OF TRANSPORTATION SERVICE IN AGRICULTURE

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SUMMARY

The general tasks of preparation, operating management and assessment of transportation in agriculture are considered. A main outcome of discussed activity is an answer of the question with how many and what kind of trucks, tractors, trailers, stories and other technical means (TM) to transport all goods for successful and profitable farming. Consecutively are discussed: determination of transportation work amount; précising of work period; selection of eligible transportation means; computing of TM basic performance indices; selection of the most appropriate TM and calculation their number; admissible organization scheme choosing for transport linked operations; haulages routing; setting of a system for transportation service assessment and stimulation; preparation of norms, recommendations and other documentation for facilitation of transportation service preparation, operating management and assessment; practical TM preparation. Because these tasks concern a lot of various problems and methods for theirs solving, a multidisciplinary approach is proposed. It includes some logistics methods for information and goods flows optimization; simulation of cars, tractors, and trailers transportation performance; specific optimizing method for duration of agricultural transport and filed processes, etc., presented here in essence and showed in details in some publications.

Key words:
technological design, transportation, agriculture,
information and goods flows

INTRODUCTION

To determine the performance of a transport service system first it has to calculate quantity of technical means. Generally the number to them can be define by next formula:

$$N = Q*L/(D*P), \quad (1)$$

Wherever N is number of transport means, Q – quantity work,
L- distance, D – timework, P – capacity of transport means

For preparation and realization of transport service is necessary to solve ten main connected tasks. They are presenting on figure 1.

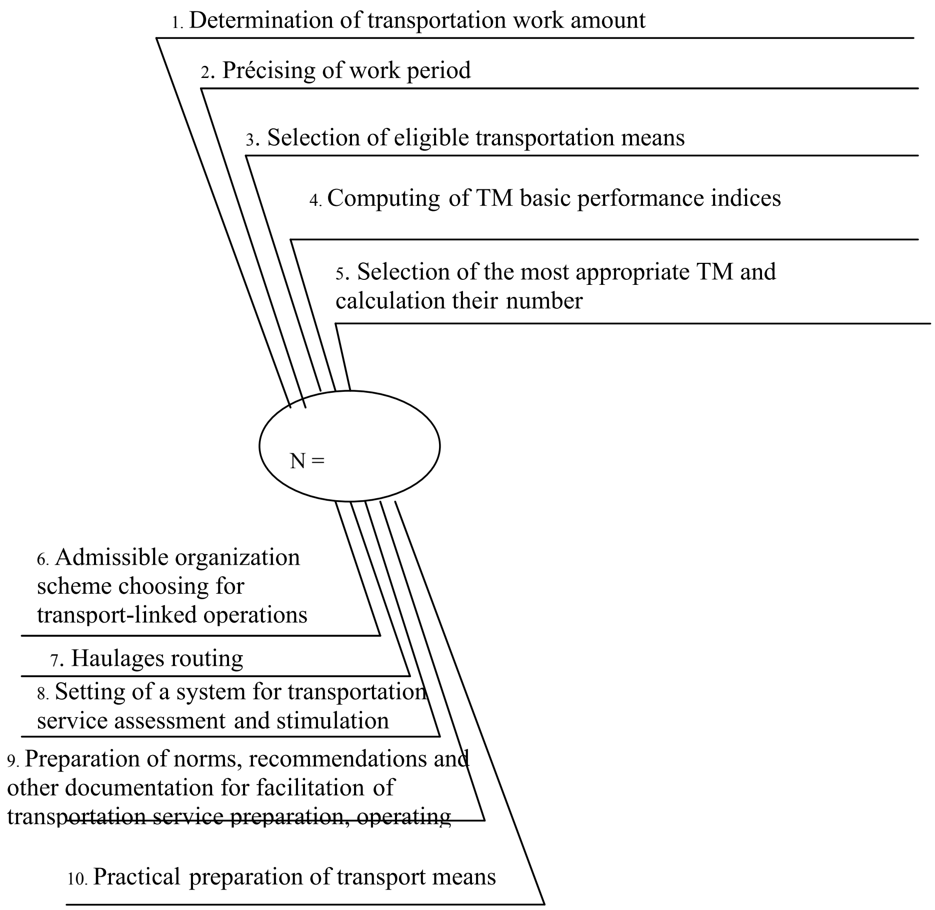

FIGURE 1. TASKS OF DETERMINE THE KIND AND NUMBER OF THE TRANSPORT MEANS N IN DEPENDING ON QUANTITY WORK Q, DISTANCE L, WORK TIME D, AND CAPACITY P

Foremost, it is necessary **1. To define the volume of the transportation work.** It is known that it is dependent on the quantity of the loads, the places of loading and unloading and the route between the last. It is accepted that the places of unloading are beforehand defined: for loads to farmyards – storage's of buying and reconstructing organizations, consumers, markets [2], [3]. The places for loading from the farmyards are: in case of direct transporting depending on the crop rotation, the places of the farms; for first-made loads - station of first making of grain, dairies and others. The places of loading the loads towards the farmyards are foremost storage's of trade organizations for fuel products, seeds, manure's and chemical preparations and others. The quantities of the loads are liable to optimization process aiming to maximum profit [13], [14], [18]. Of course not only the average of them, it is required to detect the last volumes. The length of the road can be choosing in the route [10], but sometimes on this stage the data are not enough.

After that it is important 2**. To define the duration for transportation, transfer, and storage.** The appropriate terms are those, who have enough technical means for carrying technical and transporting processes. The duration of the according processes are normally defined of the balance of agricultural products loses, the change of the prices and the expenses of higher capacity.

Usually while calculating the optimal term in the equation is included data of the machines, performs the concrete process [1], [11] и [16]. Many researchers neglect the fact that to calculate if should be know the value of the idle time. Other researchers investigating the technology of the concrete conditions are neglecting the interaction with the duration. As an example, important technological factor is the height cut in the harvesting [15], [17].

Most of the shown examples discuss the definition of the duration and the working terms of the transport operations incompletely or one side. For example, the connections with the servicing processes are not taken in account. In fact, the result depends on next in the technological row activities as drying, cleaning and storing.

Up to the moment are mentioned the quantity and time factors. For the efficiency the quality is important, as well [7]. Such factors in the harvesting are the losses in dependence with the production, the technological regulations and other similar. From this derives the necessity to suggest a procedure for more accurate and more complex estimation of the duration of transport processes. It must include the main factors of the duration of the connected operations as yield, credit duration, price of the grain, price and capacity machines and other.

It is reasonable to make a 3**. Choice of the possible technical means** by mark and kind from the beginning: railway, air, water, tractor, car, without, with one trailer or train's, load – unload immediate buffers and other [10], [13]. The transport applicability of the concrete transport or transfer, the storage applicability is appreciated for a concrete combination: load – technical mean. For example vertical transport cannot be doing with belt conveyer, auger conveyer can damage inadmissible the seeds. For expensive and quick spoiling of big distances is suitable to use the air transport.

4. To define the parameters and the indexes of each of the possible technical means of the concrete process. From a methodical point of view the assessment of the capacity, the consumption's of energy and other main characteristics for many of the cases is routine task [2], [3]. Difficulties come from the lack of concrete data, for example the influence of the humidity, presence of mixes on the productivity, arcing and storage. More difficult is to decide the task for complex of interconnected means (especially in case of bad concordance and increase of the idle time).

The obtained results are a base of **5. Choice of the most appropriate technical means and defining the necessary quantity.** Therefore it is necessary to point criteria for possible combination of technical means i.e. to approach in the view way of global optimization. This means to define the necessary transport park and storage's to this end all carries, transfers and storage's as possible as the whole crops rotation – [3] and others. It must be put down also the tendencies for change of the production program of the agriculture.

Further it is good **6. To be selected schemes for completing the production – transport processes.** Example schemes can be chosen between the described in [6], [9]. It is said a word about the combination of place and kind of technical means taking in mind there present amount the desired productivity and expenses in there mutual use. For example the transporting of straw can be happening A. from the beginning of the field B. there to be stored down and in availability of carry means V. to be loaded and transported in the agricultural court. The division of the carriage in several stages allows to transport at the end of the field by fewer transport means and to choose the time of last carriage.

Together with this or separately is necessary **7. To define the routes of movement and eventual mediate storage.** This task is yielding to automation decision - [9].

Taking the common and hardly predicted changes in the transport conditions is wish to **8. To be selected help materials** for simple and quickly deciding of the former task by nomograms, norms and standards, others manual data, applied computer programs. Such actualization of the decision should be reachable for direct directing transport service – farmers, dispatchers and other.

For the director of the agricultural and transport parks are obligatorily **9. To apply a system for assessment** (by means of complex of indexes) is stimulating the effective transport service.

At the end **10. Must be prepared promptly all technical means and loads.** This means to give necessary directions as the ways of compacting, consolidation of the loads, equipment for movement in the field and so on. The last three tasks have applicable character and are connected with the management of directing which makes them an object of other applicable fields. They generalized and make understandable and practically effective decisions of the tasks from 1 to 6.

The scrutinized tasks to run out totally the basic questions of the preparation and realized of the transport service of all connected processes (projecting, checking, changes, decision – making adapting of the decision). Due to the completely of the object the deciding of the tasks of the projection of the transport service in the agriculture cannot be realized by one step. It is necessary the returning of some stages making and global optimization.

Some of the tasks are decide reasonable, for instance from three to seven, other unfortunately demand more exact decision by means of creation of database, methods and program means for defining the proper terms for the defining of the necessary quantity of technical means (especially for not big farms for projecting of the transport service in the agriculture).

The last publications in the mentioned area - [10], [13], [14] and other, show the expedient of the decision of the following scientific tasks:

- The developed of approach and methodical means for preparation and operative technological behavior the coordinated work of transport and harvesting of cereals.
- The creating of methodical of complex evaluation of the technological efficiency in the harvesting and transport processes.
- The creating of a model of harvesting and transport processes in the harvesting for a product and two products with using of immediate buffer in different schemes of the organization of a transport service.
- The grounded of an algorithm for defining the most proper duration of interacted transport and technologic processes.
- Establishment of the basic factors and dependence's, defining the stability of harvesting and transport processes. Stability assessment of the concrete harvesting and transport processes.
- Defining of the basic factors and dependence's of the immediate buffer, influencing on the efficiency of harvesting and transport processes.
- Collecting of information for using applying the methodical of preparation and operative technological control of transport harvesting processes (cycle time, idle time and speed of moving). Receiving of data needed for determining the most appropriate terms of the transport processes (for harvesting of the grain from temperature, humidity of air and atmosphere pressure).
- The grounded and application of practical approach for preparation and operative technological control of transport and harvesting cereals.

MATERIALS AND METHODS

As object of study in this paper is grain harvesting and transport process for wheat, barley by immediate buffer using. Such process requires executing of the work in short terms, engaging of big number of technique, many workers and so on. The lengthening of the time for harvesting leads to the enlarging of the relative losses, worsen of the quality, mostly of grain and from here to diminution of the price.

The necessary data for existing technological and technical decisions include: a) extraction's of records and accounts data of agricultural farms in Razgrad; b) summaries of the result of investigations of similar conditions – [8]; c) passive experiments in real production condition and simulation of possible similar processes with the using of immediate buffers. The experiments for data collection were realized in some Northeastern Bulgarian farms during summers of 2002 and 2003. Winter wheat, barley were harvested. Yields were 3,5-4,0 and 3,3-3,5 t/ha. The stalk-grain ratio was approximately 1,2-1,25. Fields were with slope less than 3,5%. The crops were normal: not layer, without weed. The grain moisture was 9,4-18,1% days and hours variable. The air temperature and moisture was between 17 and 36 C0 and from 90% to 39% at harvesting wheat and barley.

John Deer 2264, Case International AF 1660, Massey Ferguson MF 34, 4, Claas 96 was using for grain harvesting.
The transport crop realize by cars IFA-L60 and ZIL-130 (ЗИЛ-130) and tractors with trailers Zetor-12111 + RSD-5 (РСД-5), UMZ-6L (ЮМЗ-6Л) + RSD-4 (РСД-4), T-150K + 3PTS-12 (3ПТС-12).

Weighing of the transportation crops are making by mechanical balance with maximum scope 50000 kg. The crop storage realizes in shelters, open ground, special buildings. It their capacity was enough for acceptance of the produces without idle time for next transport mean.

Besides this indices were registered cycle time, idle time, time between failures, time between recoveries of combine harvesters, transportation means, stores.

For simulation of system work for transport service was a computer-aided method is presented for main indices calculating of connected transport and field operations. As an object of simulation one real process of harvesting and transportation of two plant products is chosen. For grain transports are providing lorry with or without trailer, for other part of plant – tractor with trailer.

A simplified graphical picture of a harvesting and transportation of two-plants products process is presenting on figure 2.

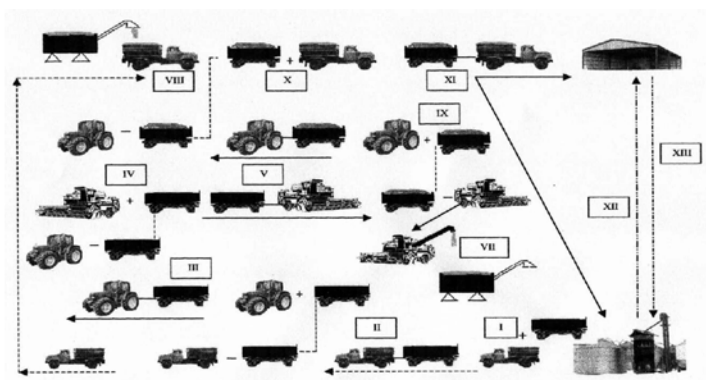

FIGURE 2. A SIMPLIFIED GRAPHICAL PICTURE OF A HARVESTING AND TRANSPORTATION OF TOW PLANT PRODUCTS PROCESS WITH SEMI – STATIONARY IMMEDIATE BUFFER

The stages are: I - coupling of empty trailer and empty lorry in the farmyard, II - travel of the road train to the end of the field and than uncoupling of this articulated vehicle, III – a tractor is coupled with an empty trailer and tractor pulls the trailer to a combine harvester without coupled trailer, IV – a solo empty trailer is coupled with a harvester, V - harvest operation of two kinds of plant products: grain and cornstalks. The gathering process stops when the harvester grain tank is full or the hauled trailer is full, VI - a selection between two choices (unloading directly in a lorry or in a immediate buffer) is simulating. The right decision depends of that if all immediate buffers are full or empty. VII - the grain tank will be unloaded in the nearest immediate buffer, VIII - grain transfer from a immediate buffer to a solo empty lorry, IX – the full trailer it is uncoupling, than coupling with a tractor and pulling to the end of the field, X - if there are full lorry and full trailer at the same time. Than they are uniting in a new articulated vehicle, XI – select the travel direction, XII - travel of full vehicle to F-KOPS, unloading of the lorry, XIII – articulated vehicle (empty lorry and full trailer) travel to and trailer is unloading in S-KOPS.

In detail the simulation of transportation service is discussed in [20].

RESULTS AND DISCUSSION

To predict interaction between harvesters, cars, trailers and stores we need to know also transportation cycle time – figure 3. The upper and lower lines present the borders variation of transportation means speed. For distance more than 7 kilometers speed was approximately constant in rural roads and off-road for experiments conditions.

This allows determining the time for weighting, tracks/trailers unloading, and documents preparing. In these cases it is about 10 minutes. That corresponds to an intercept of a function after linear regression analyzing [21].

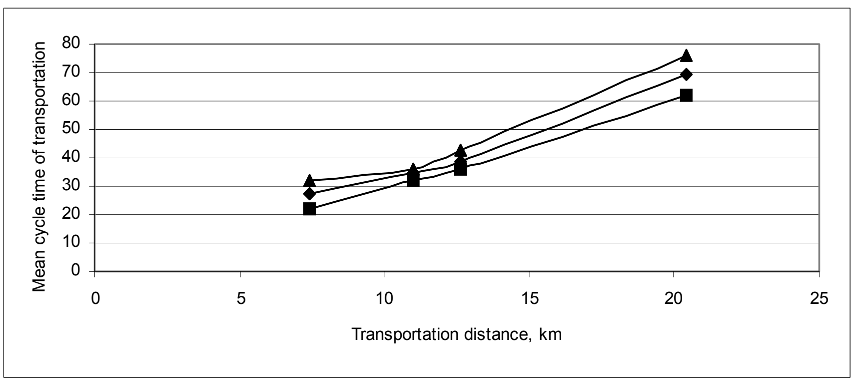

FIGURE. 3. TRANSPORT DISTANCE (TOWARD AND BACK) EFFECT ON CYCLE TIME OF HARVESTING LINKED TRANSPORTATION OPERATIONS

In our study we are investigated possibility for applications on suggested from [8] formula for determine volume of immediate buffer by aim line balances works in agricultural.

$$V_K = V_B \,.\, [M - (\lambda + \mu) / \lambda \,.\, (1 - P_0)] \qquad (1)$$

As result of computer simulation and experiment data using of real harvesting processes are receiving next dependence's [5].

On (fig.5.a) is presented changes of immediate buffer capacity V_k in dependence on ratio R of failure rate λ and recovery rate μ.

$$R = \lambda / \mu.$$

On (Fig.5.b) is showed connected between immediate buffer capacity and distance of transport in road R_0.

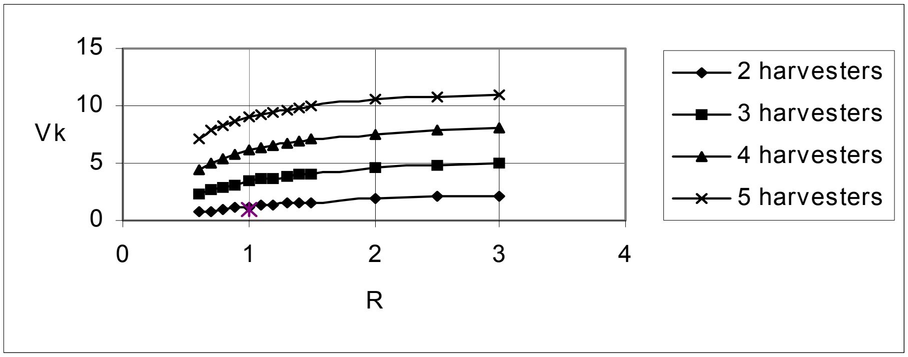

FIGURE 5. RELATION BETWEEN IMMEDIATE BUFFER CAPACITY V_K AND RATIO R OF FAILURE RATE Λ AND RECOVERY RATE M FOR TRANSPORT AND HARVESTING PROCESSES

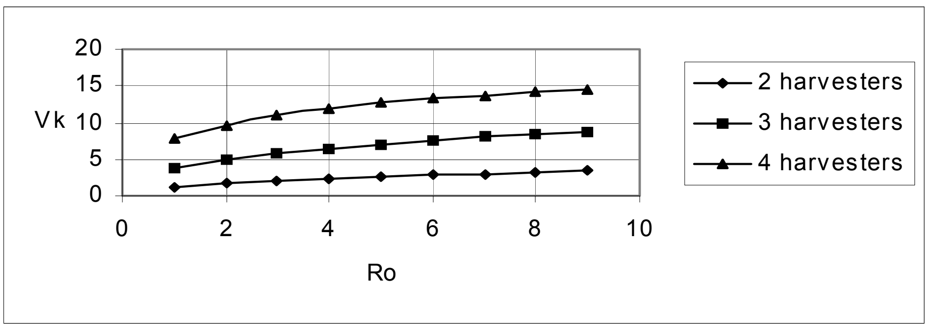

FIGURE 6. RELATION BETWEEN IMMEDIATE BUFFER CAPACITY AND DISTANCE OF TRANSPORT IN ROUT R_0.

With augmentation number of combine harvesters the immediate buffer capacity increased – Fig. 5. If we use this formula for 1 combine harvester, it is not necessary to have immediate buffer. For high R are expected idle time to be more highness and because of necessary of immediate buffer capacity is high. For save immediate buffer prices it has to be smaller, i.e. transport means to be with high capacity.

On Fig. 6 it is shown, those with augmentation of conjointly distance necessary of immediate buffer with high capacity increasing. The augmentation is more materially in more small number of harvester. In more number of combine harvester for example 4, 9 times increasing of the distance come to almost twice increasing of necessary immediate buffer capacity.

Based on this experiment result and harvester performance simulation, the relations have been determined, on relation between fuel consumption, kg/t grain, grain yield, kg/ha and straw to grain ratio. Relation between fuel consumption, kg/ton grain, cut height and straw to grain ratio have been determined in [12] are show more detail examinations.

The information shown in figure 7 presents influence recommended process duration in dependence of credit duration and grain price.

The figure show that for the present and the next year forecast prices there is no big difference: 2 – 3 days between expedient continuance for transport work. It is obvious that a loan with credit less than 2 years is unprofitable for conditions like these in Bulgaria – figure 7 – on the previous page.

This result shows that optimal duration of transportation varies in quite large interval. This is the reason to determine concrete duration for each process and each farm. For more information see [19].

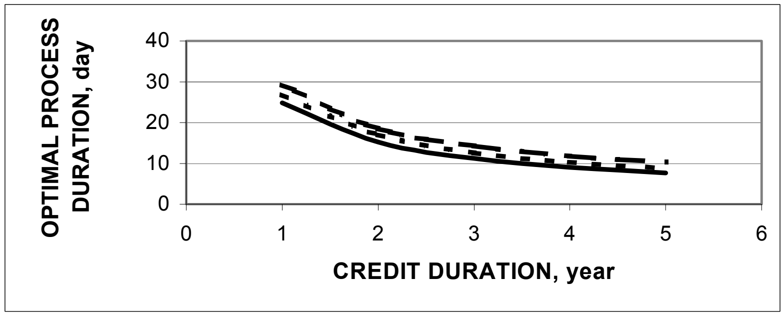

FIGURE 7. RECOMMENDED PROCESS DURATION IN DEPENDENCE OF CREDIT DURATION AND GRAIN PRICE. GRAIN PRICES ARE: 1 ------- 220 lev/t, 2 - - - - - 200 lev/t, 3 ---- ----- 180 lev/t. (1BGL ≈ 0,5106 €)

Using graphical and numerical methods for stability assessment of cereals harvesting process below are presented control charts of grain gathering and transportation subsystems as a part of one and the same harvest process [21].

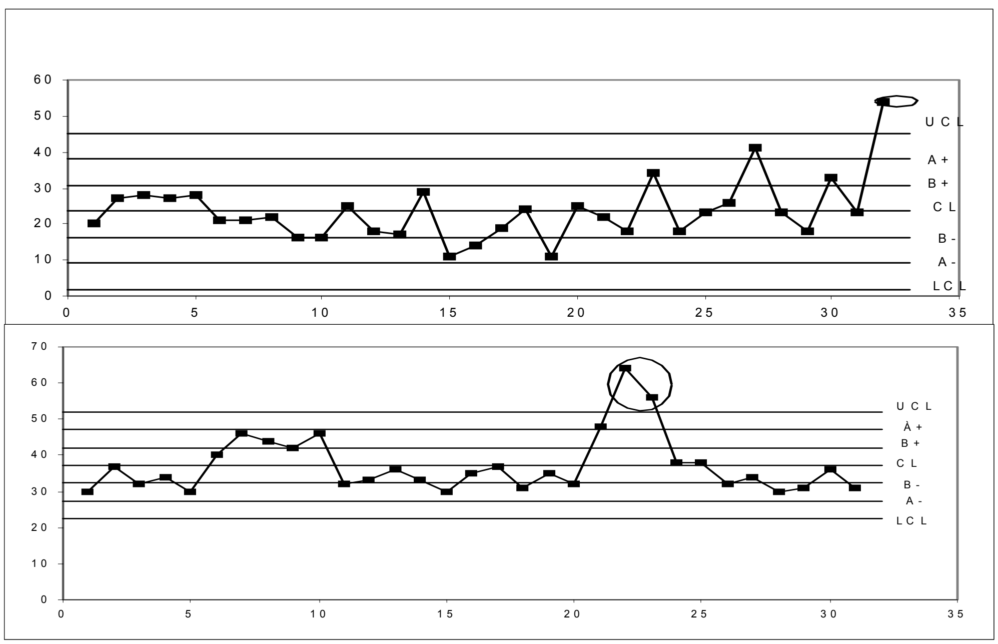

FIGURE 8. CONTROL CHARTS OF GRAIN GATHERING – A) AND TRANSPORTATION OPERATIONS – B) OF THE HARVEST PROCESS BY CLAAS 96 + CLAAS 106 + CASE INTERNATIONAL AF 1660 HARVESTERS

This two subsystems’ processes are unstable. It can be assumed that the two point outside the upper control limits for subsystem shown on Fig. 8b case effects on the trend for subsystem shown on Fig. 8a.

CONCLUSIONS

- It is proposed an approach and methods for preliminarily preparation and adaptive technological management of field and transport linked processes, based on simulation.
- A method for complex technological assessment of field and transport linked processes is developed. By another proposed method can be improve transport process stability, independently of harvest process instability.
- The process of harvesting and transportation in case of two-plants gathering using of compensator is modeled.
- An algorithm for optimal harvest duration in case of linked transportation is proposed.
- Appropriate relations between optimal buffer capacity and number and capacities of harvesters are found. By them can be achieved stable performance of 2 to 5 harvesters.
- There are found relations between time cycles, idle times, transport means velocity, and harvest indices. A casual connection of harvest and transportation stability is ascertained.

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