

PRINCIPLES AND PROBLEMS OF THE TRACTORS TRANSPORT-PULL UNITS UNITIZATION ANALYSIS

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INTRODUCTION

The mobile ground wheel machines unitization means a special section of designing and practice, including the whole complex of works on investigations, researches, creation and maintenance of peak efficiency in the operation of the new machine system consisting of the best-cooperating parts of the unit belonging to the system.

The unit as the machine system represents a new technical quality characterized by new properties, not possessed separately by the parts of the unit.

As the requests of the consumer can be satisfied only with the properties of the unit as a whole, and not of its parts, the estimation of the unit consists in the assessment of the properties of the created system. Separate designing of tractors and corresponding agricultural machines cannot provide a satisfactory optimization of units. With an increase of constructive and working processes' complexity in tractor and agricultural machines as parts of a unit, the unitization problems get a growing complexity and independent importance.

So far the unitization has been generated in the fastest growing section of the mechanics of vehicles, especially the agricultural ones. The choice of parameters of the future tractor units and their analysis is an inevitable phase of design works from the most initial stages of the development of new tractors and agricultural machines. Hence the essentially growing role of the unitization department in the design organizations. They carry out the great complex of works on the unitization of tractors with agricultural machines. They participate in the time-limited design and test iterative technologies of modification in aggregated parts, with the purpose of the maintenance of all the requirements to the unit and high potential of its functional properties. Thus constant interaction with the applied sciences, as the decisions on many unitization problems are impossible without modern information technologies, CAE,

CAD or an estimation of properties, so it is objectively necessary for an optimization of the parameters of the created units.

The above stated confirms the necessity for the creation of new methods and developments in the traditional techniques of system engineering of the unitization developed tractors, including transport trailers.

In the present article the principles and the unitization problems structure of the analysis system and the unitization coordination of tractors and transportable-power vehicles as means of transport are stated. The developed standpoints aim at the creation of conditions of essential improvement of the unitization quality and efficiency of tractor vehicles in various spheres of their application.

PRINCIPLES AND PROBLEMS OF THE UNITIZATION ANALYSIS SYSTEM

According to the purpose of unitization, the system of unitization analysis and the coordination of the parts of a complete tractor transport unit should provide an optimization of their internal and external connections and of the unit as a whole technical system in the regular conditions of its application and to represent an organizational system of the complex decision-making process as to the unitization problems, its estimations, decision-making and documenting. It is also necessary to attribute information technology to the functions of the system, the essence of which will consist in the accumulation and storage of the statistically described data connected with the unitization coordination of tractors and transport trailers.

The purpose and problems of the unitization predetermine a technique of carrying out the system analysis and the coordination as well as decision algorithms of the corresponding problems. Features of a complex of works and their order at the unitization coordination allow for an automation of the process in its significant part and for an establishment of the information technology which the above mentioned system of the unitization maintenance should realize.

It is necessary to carry out the unitization coordination of tractors with transport trailers view of all the major aspects of the unitization: constructive – geometrical; force; power; agro-technical; operational.

The constructive-geometrical unitization considers questions of the unit-connecting elements' conformity, maintenance of the required parameters of parts and relative movement of the executive device, minimization of time expenditure on the coupling-uncoupling of the unit.

The force unitization considers questions of the force analysis of the unit as a complex mechanism, calculation and maintenance connecting and safety elements durability in static and dynamic operating modes, questions of rational distribution of loadings in hinges, support and transmissions of the unit.

The power unitization solves problems of maintenance required traction, power transport and high-speed parameters of the unit due to all factors which it is possible to influence, at the minimal common and specific expenses of energy

for the performance of the working process. Here many questions of the technical optimization of the systems and the unit as a whole by technical and economic criteria are considered.

The agro-technical unitization of the transport unit considers questions of the maintenance of allowable pressure upon ground and a road surface due to design data of parts and features of their interaction in the unit.

The operational unitization covers questions of maintenance of maneuverability properties, working conditions and smoothness of a course, dynamic and course stability, stability against overturning, questions of the safety precautions, work of coupling devices, expenses of time for a running cycle, unloading – loading and other factors influencing productivity and profitability of the transport unit in a concrete set of regular conditions of operation.

During the development of new tractors and of agricultural machines intended for work in combines with them, only the main parameters of the parts of the future unit are originally known. These parameters are ordered by system of machines as a result of the development of an information level designing and definition by economic criteria of the best, physically real, combinations of the elements of dimension-type numbers of tractors and of the agricultural machines' various purposes. [1, 2].

According to the standard – “Agricultural Tractors and Machines. The Coordination of Unitization” the last one is provided from the very first stages of a macro-level designing: at the first stage – at the drawing up of the technical task and at the final one – at a ready pre-production model and tests of the unit. In the technical task the map of the unitization has been entered, and the coordination of the unitization was recommended to be finished before carrying out of the state tests.

Up till now there was a certain order of the coordination of the tractors unitization [1-3], but as follows from the analysis of practice, this work in many cases is limited to consideration of the coordination on static parameters of a tractor and agricultural machine, and dynamics is taken into account in the empirical expressions of numerous approaches, or not taken into account at all. As to the necessity for the development of the procedures of the unitization coordination, including those in the direction of the inevitable attraction of mathematical modeling, it is underlined in the works by Orlov N. M., Ksenevich I. P., Tarasik V. P.'s, etc [1].

In view of the classification and interrelation of unitization problems of the tractors the differentiated structure of problems during transport of cargoes is developed. Thus, it is necessary to take into account, that frequently the coordination of the unitization is carried out in the situation when the tractor has already been developed and released by a factory, and the prospective transport trailers for work in coupling with it are developed later. In such conditions in a design of a tractor, by virtue of its universality and possibility of work with a large, up to several hundred number of machines, it is practically impossible to introduce variations. The work is basically reduced to the adaptation of the trailer to a tractor by constructive changes of coupling devices, hitch, a forward part of a frame, support-rotating and lay devices, a suspension bracket, updating of carrying capacity, brake and hydraulic system, etc. And the most expedient recommendations on the comple-

tion of a trailer, as long-term experience has shown, are developed only on the basis of functional researches of a tractor train on mathematical models and then the subsequent control check in natural conditions.

The problems structure of the unitization of tractors with transport trailers should take into account the necessity of the observance of all the complex of the requirements to agricultural units for a particular purpose, stated in numerous standards.

The problems structure of the system of the analysis and the unitization coordination of tractors with transport trailers developed in view of the stated concept is submitted in Tab. 1.

Table. 1. The structure of the analysis system problems and the unitization coordination of tractors with transport trailers

Weight calculation of the unit	Calculation of the characteristics of the overcoming of obstacles and biases by tractor train	Calculation of transport cycle time and operational productivity
Calculation of the basic reactions of the parts and the unit in a static	Calculation and check on the permissible parameters of oscillation on the driver's seat.	Check of a coordination of coupling and safety devices
Check of loadings on controlled wheels for the maintenance of the controllability and stability of the unit	Calculation of the characteristics of the braking processes, deduction in a delayed condition, check of an acceptability of the parameters of speed, tracking, synchronism	The force analysis and calculation of mechanisms of boards opening and overturning of a platform, check of an potentiality of work in coupling with a given tractor
Check of the carrying possibility of the linking device	Estimation of maneuverability properties at the established speed of movement on a straight line and on turn, specification of weight of the trailer	Strength calculations of coupling and safety devices
Check of the sufficiency of the carrying capacity of trunks	Calculation and an estimation of maneuvering properties, harmonization in the allowed lanes	Calculation of kinematics and strength calculation of the support-lay device
Check of stability against overturning on biases and at unloading	Check of the relative mobility of parts on counter biases and at overcoming obstacles	Estimation of devices of back maneuvering
Calculation of dynamic parameters and drawing up of settlement circuits of the transport unit for the decision of the listed problems of the unitization	Estimation of power balance structure and energy loading of units, check of conformity for energy resources.	Estimation of a coordination hydraulic and pneumatic systems, their armature on parts of the unit
Carrying out of the force analysis of the design-layout mechanism of the unit and check of an admissibility of the combinations of design data	Estimation of fuel profitability and comparison with the expedient one on specific expenses	Estimation of the unit on parameters of technological level and quality and calculation of the generalized parameter of quality
Calculation of the characteristics of the process of acceleration of the unit, specification of the weight of the trailer	Calculation of the technical productivity and specific power inputs	Check on the conformity to other norms of the specifications and technical documentation
Calculation of the parameters of the basic passing ability	Calculation of the characteristics of the course stability and check of an admissibility	Filling the summary table of the unitization certification
Calculation and check of an admissibility of the normal pressure on the ground	Calculation and construction of the dynamic certification of a tractor train	Formulation of the conclusion about the unitization coordination and recommendations – restrictions

As follows from the figure an essential part of the general number of necessary and obligatory problems for the decision of the unitization make the problems of transport trailers optimisation connected to the modeling of the major operational properties of tractor trains and to the demand for multiple-parameter and multi-criterion tractors.

All the spectrum of the solved problems of the unitization can tentatively divided into three groups: 1st – maintenance of the major properties, defining technical and economic parameters of the transport unit; 2nd – maintenance of the integrity of the unit as systems, safety of work and working conditions of the driver; 3rd – the experimental acknowledgement of the correctness in decision-making.

The character of the problems of the first and second groups allows for the realization of their decision as information computer technology. Thus problems are expedient for fulfilling as program appendices with the use of technologies of spreadsheets and databases, at maintenance of information unity of the data for both groups of problems and their association in the structure of the automated unitizing subsystem of tractors.

The decisions concerning problems of the unitizing coordination, demanding research and an estimation of properties of the transport unit on mathematical models and in natural experiment are carried out after the initial constructive-geometrical and power coordination under the design of both the operational documentation of parts and their characteristics. Thus, the constructive, force and power potentialities of a tractor specified in its characteristics are compared to the corresponding "needs" of a coordinating trailer. As a first approximation the admissibility of full weight of the trailer is checked at work with the given tractor in the road conditions accepted for settlement, and at recommended speeds of the movement on the basis of the statistical data on analogues.

In the case of high energy saturated tractors, due to the speed, it is not possible to adequately realise the potential of a tractor in the unit with one regular transport trailer in easier road conditions than the ones accepted at the development of the trailer. The structure including two and more trailers is in that case considered. If trailers of different models are taken into consideration, the unitization coordination is carried out for all the trailers of the given structure.

If it is necessary to ensure the functioning with the ready-made trailer, it is practically impossible to enter any changes into their design, because of the high universality of wheel tractors. Therefore, if there are not enough variation potentialities of the tractor coupling devices for the removal of possible difficulties at unitization, constructive changes concern hook-on train regarding a correcting of coupling devices, support-lay and support-rotating mechanisms, arrangement of places of fastening-connection such as sockets, lengths of connecting armature hydro- pneumo-, electro-systems and safety adaptations, a design of a hitch and its positions before the realization of the coupling, cross-section dimensions, back visibility, systems of blocking of rotary devices at maneuvering by a backing, lay brake systems, weight of a cargo, means of a safety at an emergency separation of the trailer from the tractor, conformity of parameters of lighting

devices, etc. In some cases change of base distance, lengths of a platform and places of its fastening on a frame is necessary.

The traditional approach consists in the comparison of nominal parameters of parts of the unit and experimental check of the characteristic conditions and modes of operation typical for the created unit [1].

A competition between leading manufacturers of tractors and agricultural machines for coupling with them predetermines the necessity for the creation of highly effective competitive units. Today the development of such units objectively demands the carrying out of the multiple analysis of functional properties already at the design stage. It also calls for a multi-parameter optimization of the transport unit, hence also the wide attraction of the computer modeling means. Even with the ready-made parts of the unit, their coordination can be more effectively carried out while sharing both the modeling and experimental check of the working process of the transport unit.

The algorithm of the decision-making during the unitization coordination of a tractor with the transport trailer develops from the made decisions on the set of separate problem-checks and in a general view can be submitted as follows. Let x_{ijk} – value of i-th parameter of j-th module of k-th link of the unit,

y_{ijk} – the bottom boundary or allowable value of i-th parameter of j-th module of k-th link of the unit,

Z_{ijk} – the top value similar previous one,

$f(\bar{x}, \bar{q})_l$ – value of l-th functions of a vector of unit parameters and a vector of movement conditions \bar{q} ,

$\Phi(\bar{x}, \bar{q})_l$ – allowable boundary value of l-th functions $f(\bar{x}, \bar{q})_l$,

$P(a)_l$ – l-th the variable statement, whose validity depends on the values of argument a ,

$Q(\bar{x}, \bar{q})$ – the variable statement about the result of the unitization coordination of the unit in a spectrum of regular conditions of its work.

The check of each m of the successful positions of the coordination at unitization estimation is expressed by the inequalities of the kind

$$Z_{ijk} \geq x_{ijk} \geq y_{ijk}, x_{ijk} \leq y_{ijk} \text{ or } x_{ijk} \geq Z_{ijk}, \quad (1)$$

$$f(\bar{x}, \bar{q})_l \geq \Phi(\bar{x}, \bar{q})_l \text{ or } f(\bar{x}, \bar{q})_l \leq \Phi(\bar{x}, \bar{q})_l, \quad (2)$$

On the basis of which the final conclusion about the positive result of the unitization coordination is made

$$\exists \bar{X} \left(\bigcup_{l=1}^m (P(a)_l = True) \right) \rightarrow Q(\bar{x}, \bar{q}) = True, \quad (3)$$

where a – one of expressions (1), (2) if in expression (3) variations \bar{X} correspond only to the constructive potentialities and adjustments of parts of the real tractor unit which thus are fixed in recommendations on the unitization. Otherwise $Q(\bar{x}, \bar{q}) = False$ and the task of the finding of the positive result becomes the task of the improvement of the project of the transport unit that is connected to the constructive completions of parts by one of the above listed ways of a « small intervention in a design » about which an addition to the report of the unitization coordination is made. If in the latter case the positive decision of the unitization coordination is unattainable, use the more radical, generally known ways of improvement of the transport unit project, for example, change of the base sizes, the constructive circuit, or the running system of the trailer.

At the satisfactory decisions on each of the checks or estimations of the transport unit, the positive decision on the admissibility of the joint operation of the parts is made and their parameters, providing the best efficiency of the transport unit in operation, are established. Otherwise, the parts are changed and process repeats.

For the unitization coordination executed completely, made out by the report, results are expedient for directing to a computer database, increasing its concrete variants of units that will raise its information value for the developers and the maintaining organizations.

THE CONCEPT OF TRACTOR TRANSPORT UNITS

The suggested concept of a modern tractor transport unit, realizing new and traditional technologies, consists in its modular structure and in the maintenance of all-the-year-round use of the liberated tractor power unit and of some active working modules, in the unification of the running systems of parts and semi-automatic management of the structure and modes of incorporated mover, in the application of the new unitization principles to parts of the unit and the multiple-driving of executive devices by means of a flexible system of hydro-mechanical power take-off.

The modularity of constructions is the general tendency of development of designs of mobile machines [3], however the specificity of the tractor transport unit imposes particular features on the realization of this trend.

The basis of the modular unit is a tractor power unit as a wheel tractor or transportable-power vehicle on its base with specialized movers, universal mechanisms of unitization and systems of power take-off. With this power unit as with the unified technological chassis functional-technological transport modules are aggregated according to the purpose of the received unit.

Study of variants of structural-layout circuits of the mentioned units has shown the expediency of use of constructive principles of the unified traction and running modules sectioning, formations of rigid connectable parts, applica-

tion of an alternative drive under special conditions of movement, and also principles of system unity, compatibility, unification and standardization, a coordination and replaceability of the functional modules and the technological chassis [3]. It is obvious that with sufficient completeness the listed principles can be realized only by a group development of a new system of tractor transport units.

With reference to the considered units of the new concept development of the unitization principles, the including of new ways of the connection of the parts in the unit and the prospective constructive circuits as well as the carrying out of an analysis of the major properties is necessary for the optimization of parameters, at the account of changes of object in real operation [2]. In connection with this, the substantiation of unitization assumes system research and optimization of the unit as an essentially dynamic object in the categories of unitization.

Except for the listed principles and the above mentioned traditional ones, such principles of the structural organization and the unitization of the modular tractor unit as the principle of the flexibility axes' diversity of the unit, the principle of reserve active and running wheels, the principle of the carrying of the vertical loading from the module on the module through the hinge of their connection, the principle of the single axis joining, the principle of kinematic alignment of parts of the unit during maneuvering, the principle of cassette change of structure, the principle of the transportable-stationary unit, the principle of the liberated encapsulated engine, the principle of the forward trailer combinations [3].

From all the spectrum of modular units mechanics problems of a new generation, the most functionally significant one will consist in the maintenance of a required level of such properties of their passing ability as support-time, traction-coupling, maneuvering, the overcoming of obstacles and ecological consequences [2]. As the listed properties are determined by the structure of the unit so a consideration and development of the unitization theory is vital.

CONCLUSION

The analysis of the unitization problems of the developed tractors in the structure of transport and transport-technological units has shown that the essential difficulties in their solution will just consist in an absence of complex universal information technology of a substantiation of the unitization of tractors and transportable-power vehicles on their basis with hook-on train.

The suggested concept and the generated problems' concerning the structure of the system of the analysis and the coordination as well as the unitization principles of tractors and transport trailers will allow to take into account all their sides of the unitization, to realize problems within the framework of the automated subsystem as modern information technology open for development, in view of the latest theoretical works in the unitization area, and to thus achieve the objectives in view of the creation of tractor transport units.

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SUMMARY

This paper presents the concept and problems concerning the structure system of the analysis and the approval of tractor transport units.