A comprehensive mathematical model and the methodology for assessing technical excellence road trains with active links and all-wheel control

A N Sova¹, S A Eruslankin¹, O A Valyaev¹, I M Makeev¹, I O Sudarikov¹

¹ Department of transport installations, Moscow automobile and road state technical University (MADI), 64, Leningradsky prospect, Moscow, 125319, Russia

E-mail: a.sova@madi.ru, slsova@mail.ru

Abstract. This article presents the main provisions of the new scientific and methodological approach, integrated mathematical model and methodics assessing the technical perfection of wheeled transport means of particularly large capacity based on road trains with active links and all wheeled steering. The results of the research allowed us to justify scientific and methodological approach to the assessment of technical excellence wheeled transport means of particularly large capacity based on road trains with active links and all wheeled steering, which includes implemented conceptual apparatus, scientific concepts and principles, theoretical and practical provisions. Results of justification and developing integrated mathematical model include the total mass equations, and methodics wheeled transport means of particularly large capacity based on road trains with active links and all wheeled steering. Introduced the concept of the integrated mathematical model, justified and developed by the integrated mathematical model wheeled transport means of particularly large capacity based on road trains with active links and all wheeled steering, in which includes the equation of the total mass of transport means in absolute and relative values, equations of dynamics of sprung and unsprung masses of links of wheeled transport means, equations of joint dynamics of wheeled transport means taking into account the applications of the saddle device and all-wheel control, models of interaction of wheel propellers with the support surface, models of the micro-profile and macro-profile of the support surface, and other component parts united comprehensive model. On the basis comprehensive mathematical model proposed metodics assessment of the technical excellence of the road train with active links and all-wheel control, recommendations on the choice of indicators and evaluation criteria are justified.

1. Introduction

Modern technologies of design and the choice of technical and technological solutions when building wheeled vehicles especially big load capacity based on the application of modeling techniques and algorithmic and software complex (software packages) for their implementation allow to justify design-layout solutions, providing implementation of technical requirements the technical requirements to experimental-design works on creation of the wheel transport means especially large load capacity on the basis of road trains with active links and all-wheel control [1, 2]. Making a decision on the creation and mass production of wheeled transport means especially large load capacity on the basis of road trains with active links and all-wheel control (WV) it requires a reliable and complete feasibility study with the use of indicators and criteria for evaluating the technical excellence of the products being
created, taking into account the volume of serial production, as well as the costs of development, development of production, production, experienced working out, commissioning and service, including service station. [3, 4].

In the terms of reference for the implementation of experimental design work on the creation (development, manufacture, testing) and operation of wheeled transport means the purpose of the WV, the features and conditions of its operation, the general characteristics of the WV or WV complex and the necessary initial data must be specified. For the design, the following initial data are required: the mass of the main payload \( m_{gp} \), kg; weight of technological equipment \( m_{t,o} \), kg; dimensions, volume and centers of mass of cargo and technological equipment (dimensional drawing); minimum specific pressure on the ground \( q \), MPa; the fuel consumption \( t \), km; total warranty mileage for the entire service life \( S \), km; distribution of road conditions in % from the total mileage; overall or road-legal restrictions; maximum speed of movement \( v_{max} \); values of the minimum \( D_{min} \) maximum \( D_{max} \) dynamic factors [5-8].

The procedure for preliminary calculations and identification of the general structural and layout scheme of the WV and its base chassis on a specific example is considered in [9]. When developing structural and layout schemes of WV and special automotive base chassis (ABCH), it is necessary to take into account the experience of creating their analogues and prototypes, represented by statistical data on the completed structures, given in the [5, 9].

In the section «comprehensive mathematical model of a WV» the article presents the results of justification and development comprehensive mathematical model.

2. Comprehensive mathematical model of a WV
Mathematical model WV – this is the way (prototype) WV, represented by mathematical symbols and relations which allows to investigate the properties of WV, determining its technical excellence and degree of conformity of the achieved result of the application of WV desired result, specific technical requirements, different conditions. Comprehensiveness of the mathematical model of WV is determined by its unity and the number of factors that affect the technical perfection of WV, taking into account its structure, characteristics, modes and operating conditions. Comprehensive mathematical model wheelbase transport means especially large load capacity on the basis of road trains with active links and all-wheel control includes the equation of the total mass of WV in absolute and relative values, the equations of dynamics of sprung and unsprung masses of WV links, the equations of joint dynamics of WV links taking into account the use of a saddle device and all-wheel control, models of interaction of wheel propeller with seating surface, models of the micro profile and macro profile of the reference surface, and others component parts single comprehensive model [1, 2].

The total mass of any WV can be represented as an equation [5]:

\[
m_0 = m_t + m_{wa} + m_r + m_{upr} + m_f + m_{dop} + m_{up} + m_{sp} + m_p, \text{ kg,} \tag{1}
\]

where \( m_0 \) – gross weight vehicles (WV) with cargo, kg; \( m_t \) – weight of the frame (body), including load-bearing elements(spars), cross-links, bumpers and towing devices, frame brackets, control cabins and tail, kg; \( m_{wa} \) – weight of WV wheel movers, taking into account the weight of tires, rims and hubs with bearing units, central pumping system and tire air,kg; \( m_r \) – weight of the springing system, taking into account the weight of the guides, elastic and damping elements, as well as the control and stabilization system of the housing, kg; \( m_{upr} \) – weight of chassis controls including power steering, wheel brakes, air receivers, etc.,kg; \( m_{sp} \) – weight of hydraulic supports of the hanging system, kg; \( m_f \) – fuel weight including fuel tanks and fuel equipment located outside the engine, kg; \( m_{dop} \) – weight of additional equipment of the basic machine, including electrical equipment, spare parts, tools and accessories (SPTA), winches and other unrecorded mass, kg; \( m_{up} \) – weight of the power plant, taking into account the weight of the engine, its service systems, coolant and oil, kg; \( m_{p} \) – the mass of the powertrain given the wheel gear and actuator control, kg; \( m_r \) – the mass of the payload taking into account the technological equipment and technical systems for cargo service, kg.
In relative (specific) parameters, the equation (1) it will have the following form [5]:

\[ I = \xi_r + \xi_{su} + \xi_u + \xi_{upr} + \xi_t + \xi_{op} + \xi_{dop} + \xi_{su} + \xi_{tp} + \xi_p, \]  

(2)

where \( \xi = \frac{m_i}{m_0} \) relative masses of elements on the right side of the equation (1).

Based on the analysis of statistical data and design experience, all elements of the WV mass equation can be divided into three main groups. The first group includes elements of the chassis (frame, wheel propellers, etc.), the mass of which does not depend or practically does not depend on the WV energy capacity taken into account, but is determined mainly by the level of cross-country ability, permissible overloads, materials used and design quality. The second group includes elements (power plant and chassis transmission), the mass of which significantly depends on the energy capacity of the WV. The third group includes elements that make up the WV payload, including the transported cargo and technological equipment (TE) for its installation and maintenance.

For the first and second groups of elements, we introduce the notation [5]:

\[ \xi_k = \xi_r + \xi_{su} + \xi_u + \xi_{upr} + \xi_t + \xi_{op}. \]  

(3)

\[ \xi_{su} = m_{su} \cdot N_{u.e.} \]  

(4)

\[ \xi_{tr} = m_{tr} \cdot N_{u.e.} \]  

(5)

where \( m_{su} \) and \( m_{tr} \) – specific reduced masses of the power plant and transmission, respectively, kg/kw: \( m_{su} = m_{su} / N_p \eta_e \); \( m_{tr} = m_{tr} / N_e \eta_e \eta_{tr} \) – rated power of the power plant, kW; \( \eta_e = \eta_{tr} \eta_{tr} \) total efficiency, taking into account the power consumption for the engine's own needs (\( \eta_e \)), on the steering wheel (\( \eta_{tr} \)) and losses in the transmission (\( \eta_{tr} \)); \( N_{u.e.} \) – total efficiency, taking into account the power consumption for the engine's own needs WV, kW/kg: \( N_{u.e.} = \frac{N_e \eta_e}{m_0} \).

By solving the equations (2) relative mass of the payload (\( \xi_{PN} \)) taking into account the equations (3), (4) and (5), we get [5]:

\[ \xi_{PN} = 1 - \xi_k - (m_{su} + m_{tr}) \frac{N_{u.e.}}{N_{u.e.}}. \]  

(6)

When designing the base chassis for a transport or any other WV, the source data specifies the full \( M_{PN} \). When designing the base chassis for a transport or any other WV, the source data specifies the full \( M_{PN} \) and \( m_p \) is given, and there are dependencies for determining the components of the equation (3) \( \xi_c \) and the specific reduced masses in the equations (4) and (5), then at a given power level \( N_{u.e.} \) can be found relative \( M_{PN} \) \( \xi_{PN} \) by the formula (6), after that, the total mass is determined \( WVm_o \) and all its components:

\[ m_o = \frac{m_p}{\xi_p}, \text{ kg,} \]  

(7)

\[ m_i = m_o \xi_i, \text{ kg,} \]  

(8)

Data on the accumulated statistical material and analytical expressions for calculating the relative masses of the elements of the base chassis are given [6-8]. Consider the procedure for preliminary calculation of the total mass of the WV \( m_o \) for the case that \( M_{PN} \), including the weight of the cargo being transported \( m_g \) and \( TE \) \( m_{t.o} \), given, i.e. the value of \( m_p = m_g + m_{t.o} \) is known. In this case, to determine the mass \( m_o \) it is necessary to determine the mass of the base machine \( m_{b,M} \). Since the total mass WV \( m_o \) is determined as follows:

\[ m_o = m_p + m_{b,M} = m_g + m_{t.o} + m_{b,M}. \]  

(9)
To determine the mass \( m_{b,m} \) it is customary to use the WV-specific parameter – load capacity factor \( K_p \), equal to the ratio \( M_{PN}m_p \) to the mass of the base machine \( m_{b,m} \):

\[
K_p = \frac{m_p}{m_{b,m}}.
\]  

(10)

Thus, summing up the mass of the actual cargo \( m_{gr} \), technological equipment \( m_{to} \) including the mass of autonomous energy sources and fuel reserves for a given autonomy, the total mass of the payload is obtained \( m_p \). If this transported mass is placed in the body, then the payload also includes the mass of the body (tare) \( m_{to} \). Then, given the coefficient \( K_p \), from the formula (10) determine the mass of the base machine:

\[
m_{b,m} = \frac{M_{PN}}{K_p} + m_{b,m}.
\]  

(11)

The above method of approximate determination of the total mass can be applied only if all the data necessary for the determination are available or specified \( M_{PN}m_p \). However, in the technical specification for the development of WV, the weight of the cargo can be set, a mass of technological equipment \( m_{to} \) unknown and must be determined in the process of calculating the total mass WV.

In this case, for the approximate calculation of the masses \( m_{b,m} \) and \( m_{b,m} \), the method given in [5] can be used. Analysis of statistical data on the mass characteristics of various multiaxial WV showed that the stable dependences between the masses \( m_p, m_{gr} \) and \( m_{to} \) missing. The most stable parameter for WV with different load factors (\( K_p = 0.8...2.0 \)) turned out the ratio of the mass of the base machine \( m_{b,m} = m_0 - m_p \) to weight WV without load \( (m_{agr} = m_0 - m_{gr}) \). Denoting this relation by \( \theta \), based on the statistical data, we get [5]:

\[
\theta = \frac{m_{b,m}}{m_{agr}} = \frac{m_0 - m_p}{m_0 - m_{agr}} = \frac{1 - \xi_p}{1 - \xi_{gr}} = 0.62...0.65.
\]  

(12)

In the expression (12) weight \( m_{agr} \) specified, the value \( \theta \) accepted within the limits of \( \theta = 0.62...0.65 \), relative \( M_{PN} \xi_p \) it is determined by the load capacity factor [5]:

\[
K_p = \frac{m_p}{m_{b,m}} = \frac{m_p}{m_0 - m_p} = \frac{\xi_p}{1 - \xi_p} = \frac{K_p}{1 + K_p}.
\]  

(14)

Therefore, there are data for an approximate calculation of the mass \( m_0 \) the original masses:

- payload \( m_p = \xi_p \cdot m_0 = \frac{K_p}{1 + K_p} m_0 \);
- technological equipment \( m_{to} = m_p - m_{gr} \);

(15)

the basic machine \( m_{b,m} = m_0 - m_p \); WV without cargo \( m_{agr} = m_0 - m_{gr} = m_{b,m} + m_{to} \).

Next determined by the method, described in [6 – 8], the wheel diameter \( D_{sh} \) at a given specific pressure on the ground \( q_{min} \):

\[
D_{sh} = \frac{m_{as}}{2} q.
\]  

(16)

The relative weight of the frame is calculated after the design and layout scheme of the chassis or WV is developed. The method of determining the relative masses of WV and ABCH is sufficiently fully justified, developed, presented in [5] and includes the determination of the relative mass: 1) frames (with spar and tubular cross-sections); 2) WV wheel propellers; 3) springing systems; 4) machine controls; 5) fuel; 6) additional equipment (electrical equipment systems with batteries, SPTA and other unaccounted for equipment); 7) power plant; 8) transmissions (mechanical, hydrodynamic (hydro-mechanical),
hydro-volume, electric on direct current, electric on alternating current with the use of valve-inductor electric machines, electric machines on permanent magnets).

The relative mass of the power plant and transmission depends on the accepted specific effective power of the machine \( N_{u,e} \), which, according to the power formula, determines the maximum speed \( v_{\text{max}} \) of movement for a given dynamic factor \( -D_{\text{min}} \):

\[
N_{u,e} = \frac{g \cdot D_{\text{min}} \cdot v_{\text{max}}}{3600} \cdot \frac{kW}{kg},
\]

where \( g \) – acceleration of free fall; \( g = 9.81 \text{ m/s}^2 \).

Technological equipment (TE) is a component part of a machine or mobile unit (lifting, road-building, road-harvesting and other machines), which ensures that the machine or mobile unit created on the basis of a certain WV or ABCH, its purpose and performance of technological functions and operations defined by the technical task. WV or ABCH-based maintenance includes elements of metal structures, various mechanisms, their drives, power supply systems, communications, temperature and humidity maintenance, etc., as well as auxiliary equipment and SPTA. The method of determining the mass of elements of technological equipment are also adequately and reliably justified, developed, presented in [5, 9] and offers a lot of technological equipment in general, can be defined as relative mass of mechanical equipment, the masses of all the systems, that ensure the functioning of the WV and masses of accessories and spare parts WV, including masses: 1) supports (jacks and base plates); 2) pumping station; 3) Autonomous power source (AIP); 4) cooling-heating installation (henna); 5) accessories and spare parts; 5) mechanical equipment (cargo boom, front boom support, boom sub-axle beam, WV support brackets, fencing, boom lifting drive, power drive and pumps, hydraulic lines and other mechanisms and drives.

3. The methodology for assessing the technical excellence of wheeled vehicles of particularly high load capacity based on road trains with active links and all-wheel control.

The methodology for assessing the technical excellence of wheeled vehicles of particularly high load capacity based on road trains with active links and all-wheel control is based on the integrated WV model, indicators and criteria for evaluating its technical excellence. The technical level and efficiency of using any WV as vehicles is mainly determined by the specific energy capacity, that is, the specific power \( N_{u,e} \) which is implemented on the driving wheels of the units [5, 9]:

\[
N_{u,e} = \frac{N_e \cdot \eta_E}{m_o}, \frac{kW}{kg},
\]

where \( N_e \) – rated power of the running engine (power plant), kW; \( m_o \) – full weight of PA, kg; \( \eta_E \) – total efficiency, which takes into account the power consumption for the engine's own needs, steering drive and transmission losses.

Let's consider the influence of specific energy intensity on specific characteristics of WV:

\[
u_{\text{max}} = \frac{3600 \cdot N_{u,e}}{g \cdot D_{\text{min}}}, \text{km/ч},
\]

where \( N_{u,e} \) – specific energy capacity, kW/\( kg \); \( D_{\text{min}} \) – the minimum dynamic coefficient specified in the terms of reference; \( g \) – acceleration of free fall; \( g = 9.81 \text{ m/s}^2 \).

For example, from formula (19) it can be seen that for a given minimum dynamic factor \( D_{\text{min}} \) value \( N_{u,e} \) largely determines the value of the maximum speed of the unit. On the other hand, if the required speed of the unit is set at a certain value of the dynamic factor, then the required specific effective power is uniquely determined. Value \( N_{u,e} \) it has a significant impact on the mass characteristics of the unit. In this regard, it is necessary to justify the choice of certain criteria for technical excellence, which will allow you to reasonably, fully and reliably assign the value \( N_{u,e} \) in accordance with each specific problem situation, in order to ensure the effective use of WV and / or ABCH, taking into account its technical level indicators that characterize the load capacity, performance, efficiency, etc. To assess the
performance of WV and/or ABCH of different weights, it is advisable to use them \( \Pi_y \), that is, the work of transporting the payload by mass \( m_n \), per unit of total mass of the unit \( m_o \):

\[
\Pi_y = \frac{1 - \xi_k}{D} N u_e (m_{tu, su} + m_{tu, tr}) N^2 \gamma_o, \text{ kW/kg},
\]

(20)

where \( G_n \) – useful weight of the transported cargo, \( H; V \) – the speed of movement of the unit, km/ch; \( g \) – acceleration of free fall, m/s\(^2\); \( \xi_n \) – the relative mass of the payload.

Exploring the expression \( \Pi_y = \Pi_y(N_{y, 3}, \xi_k, D, m_{tu, su} + m_{tu, tr}) \) to the maximum and determine the optimal value of the specific energy capacity \( N_{y, 3, opt} \):

\[
N_{y, 3, opt} = \frac{1 - \xi_k}{2(m_{tu, su} + m_{tu, tr})} \text{ kW/kg}.
\]

(21)

Maximum value of the indicator \( \Pi_y: \Pi_y_{max} = \frac{1 - \xi_k}{4(m_{tu, su} + m_{tu, tr})} \text{ kW/kg}. \)

(22)

The maximum specific performance depends on the road conditions, that is, the lower the required value \( D \), the higher \( \Pi_y_{max} \). The technical level of WV and / or ABCH can also be estimated by the specific effective fuel consumption – the fuel consumption per unit of transport useful work:

\[
g_{y, 3} = \frac{g_e N_{y, 3}}{\eta_2, \Pi_y} = \frac{g_e D}{\eta_2[1 - (m_{tu, su} + m_{tu, tr})N_{y, 3}]}, \text{ kg} \cdot \tau / \text{kW} \cdot \eta
\]

(23)

where \( g_e \) – specific fuel consumption in the engine, kg/\( \tau \)/kW/\( \eta \); \( \eta_2 \) – overall efficiency of the power plant and transmission.

As can be seen from the expression (23), the minimum value \( g_{y, 3} \) should be achieved when \( \xi_p_{max} \). However, the value of \( \xi_p_{max} \) meet, \( N_{y, 3} = 0 \). Therefore, the optimal value of energy capacity according to the criterion \( g_{y, 3} \) does not exist with growth \( N_{y, 3} \) value \( g_{y, 3} \) it will continuously increase. Given that the relation \( \Pi_y \) it has an extremum (maximum) and characterizes both efficiency and productivity, let's take it as an indicator of the efficiency of using WV and / or ABCH and call it economic productivity:

\[
\mathcal{E}_y = \frac{\Pi_y}{g_{y, 3}} = \frac{\eta_2 (1 - \xi_k) N_{y, 3}}{D^2 g_e}, \text{ kW/kg/} \text{kW} \cdot \eta.
\]

(24)

The study of the extremum of the expression (24) allows us to determine the optimal value of the specific energy intensity \( N_{y, 3, opt} \):

\[
N_{y, 3, opt} = \frac{1 - \xi_k}{3(m_{tu, su} + m_{tu, tr})} \text{ kW/kg}.
\]

(25)

at which economic productivity takes the maximum value:

\[
\mathcal{E}_{max} = \frac{4 \eta_2 (1 - \xi_k)}{27g_e D^2 (m_{tu, su} + m_{tu, tr})} \text{ kW/kg/} \text{kW} \cdot \eta.
\]

(26)

The technical excellence of WV and / or ABCH is determined by the value of the load factor \( K_p \), by which is meant the relation \( M_{PN} m_n \) to the mass \( m_{6, u} \):

\[
K_p = \frac{m_p}{m_{6, u}} = \frac{\xi_n}{1 - \xi_n} \frac{1 - \xi_k - (m_{tu, su} + m_{tu, tr})N_{y, 3}}{\xi_k + (m_{tu, su} + m_{tu, tr})N_{y, 3}}.
\]

(27)
Based on equation (27), the expression of the maximum value $E$ it has the form:

$$N_{u.e.opt} \approx \frac{1}{3(m_{u.su} + m_{u.tr})} \sum_{i=1}^{n} k_i \xi_i \, \text{kW/kg},$$

$$E_{max} = \frac{1}{4.87(m_{u.su} + m_{u.tr})} \frac{1}{(1-\xi_k)^4} \, \text{kW/kg},$$

As an indicator of the feasibility assessment of the unit may be taken unit cost of useful transport work, that is, the transport cost per unit of useful work, taking into account the cost of construction of the unit and the cost of fuel consumed for period of operation [10]. The total unit cost of a unit of operating conditions of WV and / or ABCH:

$$C_{u.agr} = C_{u.k} (1 + K_{\theta}) \xi_k + C_{u.su} (1 + K_{\theta}) \xi_{su} + C_{u.tr} (1 + K_{\theta}) \xi_{tr} = C_{u.k} (1 + K_{\theta}) \xi_k + (C_{u.su} m_{u.su} + C_{u.tr} m_{u.tr}) (1 + K_{\theta}) N_{y,3}, \text{rub./kg},$$

where $C_{u.k}$ - unit cost of the basic machine design, rub./kg; $C_{u.su}$ - unit cost of the power plant, rub./kg; $C_{u.tr}$ - unit cost of transmission, rub./kg; $C_{u.t.o}$ - unit cost of technological equipment of the unit, rub./kg; $\xi_{r_0}$ - the relative mass, equal to the ratio of its mass $m_{r_0}$, to the total weight of the unit $m_o$, $\xi_{r_0} = \frac{m_{r_0}}{m_o}$.

Per-unit work $A_y$ for the entire service life of $T$ is determined as follows:

$$A_y = \Pi_y T = \frac{T(1-\xi_k - m_{u.su} + m_{u.tr})}{D} \, \text{kW/kg},$$

where $T$ - motor mileage allowance unit for the service life, ch.

The unit cost of useful transport work due to the cost of fuel is expressed as

$$C_{y.tr} = C_T g_{y,3} = \frac{C_T g_{e.D}}{n_2 [1 - (1-\xi_k - m_{u.su} + m_{u.tr}) N_{y,3}]} \, \text{rub./kg},$$

where $C_T$ - the cost of one kilogram of fuel, rub/kg.

The total unit cost of useful transport work, taking into account (6), is written as:

$$C_y = C_{y.agr} \frac{A_y}{C_y} = \frac{n_2 D (1 + K_{\theta}) [C_{u.su} \xi_k (C_{u.su} m_{u.su} + C_{u.tr} m_{u.tr}) N_{y,3}]) + C_T g_e D T N_{y,3}, \text{rub./kg}.}$$

Thus, the unit costs of the structural elements of the unit depend on a large number of factors and therefore vary widely, they are significantly influenced by the scale of production (annual output) and wholesale prices [10]. Analysis of the results of studies of the technical perfection of wheeled vehicles of extra large carrying capacity based on road trains with active links and all-wheel control allowed to justify and develop a methodology for its assessment, which includes the following main stages: 1) formation of databases of absolute and relative (specific) masses of WV and / or ABCH and their components; 2) preparation and input of initial data on WV and / or ABCH, their purpose, design and layout solutions, characteristics and operating conditions; 3) modeling of WV and/or ABCH using a complex mathematical model of a WV and / or ABCH; 4) evaluation of indicators of technical excellence of a WV and / or ABCH; 5) justification of the choice of design-layout solutions WV and/or ABCH, technical solutions, technical and operational characteristics of their components; 6) the synthesis of control algorithms for power distribution between driving wheels, the control algorithms for steering wheels, control algorithms for elastic and damping characteristics of the suspension system, algorithms, electronic brake control, etc.; 7) substantiation of general, technical, operational, cost and private (special) requirements.
4. Conclusions

In connection with the foregoing rationale for decisions about the establishment and further operation of WV and/or ABCH should be based on a detailed multivariate study of the competitiveness of the variants WV and/or ABCH by criterion «efficiency (compliance result in the creation and implementation (implementation) of WV and/or ABCH required (desired), technical excellence)- cost-feasibility».

The rationale for the decision on the feasibility of establishing WV and/or ABCH selection of comprehensive and private indicators and criteria for assessing the technical level and efficiency is determined by the appointment of WV and/or ABCH, the possibility of effective use of WV and/or ABCH taking into account the indicators characterizing economics and technical excellence for the lifting capacity, maneuverability, performance, speed, stability, smoothness, etc.

The results of the research allow us to formulate general and specific recommendations for the selection of indicators and criteria for technical excellence, for example: 1) the optimal energy capacity should be assigned in accordance with the criterion or set of criteria that most fully characterize the purpose of WV and / or ABCH; for example, if a WV and/or ABCH is created for which high dynamic qualities (performance) are most important, even at the expense of efficiency or load capacity, then as a criterion for \( N_{\text{y, opt}} \) you should take the specific performance \( P_{\text{y}} \); this class of vehicles includes passenger cars, off-road vehicles, tracked vehicles, etc.; 2) if a multi-purpose WV (ABCH) is designed, then the E indicator should be taken as a criterion for optimizing energy availability; 3) if the transport of undivided large-mass cargo using WV (ABCH) - based vehicles plays a decisive role, then the indicator should be taken as the number of criteria \( \Pi_k \) or \( \exists_{\min} \); 4) assigned power capacity of the unit \( N_{\text{y, opt}} \) it must provide: the required maximum speed of movement under the conditions of use of the unit for its intended purpose in given road conditions; high values of the indicator (s) of the technical level of the unit, which is achieved by choosing the optimal (or close to it) value \( N_{\text{y, opt}} \), determined by the criterion that characterizes the most important properties of the unit at a given payload.

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