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AGRICULTURAL TRANSPORT − THE TYPE AND STRUCTURE FORMATION OF WHEELED VEHICLES FLEET

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Abstract

Technological transport in the agricultural sector (domestic transportation from the "field − warehouses") is economically significantly different from the usual road freight transport. First of all, this is due to the specifics of traffic conditions (a significant share of which is dominant in domestic traffic on agricultural holdings) is off−road and field roads. Secondly, the uneven seasonal distribution of traffic volumes during the year is pronounced. Thirdly, the coexistence in domestic transportation of both automotive equipment and wheeled tractors with trailers. The collapse of the previous Soviet era, the collective farm system of the agrarian economy and the gradual formation of large agricultural holdings on the one hand and large farms on the other, led to the problem of appropriate formation of a rational type of agricultural machinery, which obviously has its own specifics primarily in terms of agri-environment, including the structures themselves in comparison with the usual freight transport for paved roads.

Key words:

agricultural transport, off −roads, trucks and tractors with trailers, type, agro-ecology.

Introduction

Increasing the productivity of grain cleaning separators affects the expenses and cost of post-harvest grain processing and seed preparation. The main technological indicators of separators for grain cleaning and calibration of seed materials are productivity and quality of separation of their components. These indicators are consistent with each other, but the quality is regulated by the standards of a particular country or international ISO, for example (ISO 605:1977, ISO 7970:2021).

Objective to conduct a comparative analysis of research results in the EU on the effectiveness of the use of heavy agricultural tractors and trucks with trailers for technological agricultural transportation and to assess the formation of a rational type of this equipment in Ukraine.

Traffic conditions and the nature of transportation (and ultimately the vast majority of the range of goods themselves) of wheeled transport in the agricultural sector of the economy differ significantly from the usual trucking by roads of I and II categories. This applies to: a significant, in fact, the dominant share of roads are dirt and off−road (agricultural land − part of the transport process in crop production, including in the spring and autumn with wet soils), which leads to special requirements for the possibility of wheeled vehicles, one side and the so-called agri-environmental structures (i.e. the impact of compaction of the top layer of soil by the wheels of machines during the movement on the fertility of agricultural land). This imposes special requirements on wheeled vehicles (not only trucks, but also wheeled tractors with trailers) in terms of allowable specific pressure on the ground (support surface), which is obviously fundamentally different from the usual weight of 12 tons per axle for trucks on roads of I and II categories with asphalt−concrete pavement. Let us consider the inevitable participation of wheeled vehicles in the technological processes of agricultural production in the fields, where agri-environmental restrictions on the allowable pressure in the area of contact of tires with the ground, according to legislation (Ignatov, 1978), especially during spring work with typically the highest moisture content in the upper layers 50−100kPa, and 60−140 kPa in summer and autumn (depending on the degree of humidity). That is, according to the results of research (Elisaev *et. al* 1984), the domestic wheeled tractor T−150K with a gross weight of 8.4 t + 1.7 t load on the coupling device from a two−axle trailer 1PTS−9

with a gross weight of 14.9 t (−1.7 t) only 24−26% of agricultural lands of Ukraine in the spring−autumn periods of intensive agriculture are operated without violating agri-environmental requirements. The use of a truck with a similar load of 10 tons (gross weight 18.4 tons), even with atypical for this class wheel scheme type Kamaz−53212 due to a significant reduction in the area of contact of tires with the bearing surface (tires 260−508R compared to 23.1 R26 in T−150K) does not meet the regulatory requirements of agro-ecology (Elisaev *et. al* 1984). This is especially true of the currently dominant in this class total weight of 18 tons of two−axle trucks with a real load on the rear axle of about 12 tons. The problem of devastating agro−ecological impact of increasing specific pressure on the soil in light of the growing productivity of agricultural machinery, and hence the capacity and weight of both trucks and tractors, similarly previously recognized as decisive for reducing yields and degradation of agricultural land in the EU (Gisi *et. al* 1997), where relevant legislation has already been adopted and is being adopted to prevent the degradation of agricultural land.

Crawler tractors with significantly lower specific pressure on the ground at a comparable gross weight, in domestic transport works are not competitive with wheeled vehicles due to 2−3 times lower technical speeds, 3−5 times higher linear fuel consumption are practically not used. Wheeled tractors, on the other hand, are widely used, but the impact on soil degradation depends significantly on the total weight of the tractor (traction class).

Formulation of problem

Significant changes in the type and structure of the fleet of tractors and cars in agricultural production over the past 20−30 years compared to the practice of 1970−80 led to the dominance of light wheeled vehicles in family and small farms and heavy in agricultural holdings and large farms. In fact, heavy machinery used on most agricultural lands is critical to agri−environmental conditions (despite its advantages in productivity and energy consumption). This problem, however, is practically not covered in domestic studies, but enough attention has been paid in foreign studies, including recently in Russia (Gisi *et. al* 1997). It should be noted the emergence of domestic research on the tractor fleet in terms of agro-ecology (Bernhardt *et. al* 2014).

The average volume of domestic traffic per 1 ha of arable land is from 3 to 12 tons (mineral and organic fertilizers, seeds, crops) − depending on the type of crop and agricultural technology.

When using modern intensive agricultural technologies, which is typical for large farms − agricultural holdings, the number of wheeled vehicles in the field on the width of cultivation or harvesting of other machine−tractor units, depending on the type of crop, is according to (Bernhardt *et. al* 2014) from 2 to 6 passes and the total number of passes of wheeled vehicles in the field from 5 to 15, i.e. the total area of traces of 25−50% of the cultivated field, which due to compaction and degradation of topsoil in turn causes a decrease in yield by 20−30% (for example grain cultures).

The main volume of transport work in agriculture is accounted for by domestic transportation, i.e. dirt roads and cultivated fields (according to (Bernhardt *et. al* 2014) up to 75−80% of the total volume of traffic − in the end the above 3−12 tons of fertilizers, seeds, crops for each hectare of arable land (Völkl *et. al* 2011). The ratio in the performance of these works by trucks and tractors with trailers during the production period was almost in close proportions of 60:40 (Völkl *et. al* 2011), but it should be noted that in 1970−80 in the agricultural sector of the USSR was dominated by 2−3 times lighter in terms of operating weight of tractors and trucks (MTZ 80 − 3.6−4t and trailer 4−6t, GAZ 52/53 − 5.2−7.4t), which lost in productivity to the next (and already available at that time in USA and Western Europe) generation of agricultural wheeled machines. However, it should be noted that already in the 1980 s in the USSR began mass production of the next (in relation to MTZ and GAZ) generation of more energy−efficient agricultural machinery tractors T−150 and T−150K (traction class 3.0t compared to 1.4t in MTZ) and specialized trucks HAZ 4540 scheme 4x4 (gross weight 12.26 tons and a load of 5.5 tons compared to GAZ with a load of 1.5−3.5 tons) and three−axle URAL 377 scheme 6×4 (load 7.5 tons and a gross weight of 15 tons), which were equipped with two−axle trailers with a load capacity of 5 and 7 tons, respectively (Ipatov, 2008).

In fact, it is possible to state the emergence of already specialized trucks (actually dump trucks with 3−way unloading of the body, which is 55−65%) trucks KAZ and URAL, characterized by the presence of all−wheel drive, wide tires, variable transmission range, which provided confident movement off−road with speeds of 6−15 km/h, according to technological speeds of machine−tractor units and combines on field works. It is fair to say that GAZ 52/53 trucks, which were used in various other areas, were still targeted as general purpose vehicles, not for fields and off−road. The objective need to develop the organization of production of trucks / road trains specialized in domestic technological transportation in agriculture was confirmed by the corresponding development of all−wheel drive equipment in Europe (almost after the Second World War − in Germany MB Unimog, in parallel now − all−wheel drive modifications MB Vano, MB Atego, MB Zetros, usually with a gross weight of 8 to 18 tons). Finally, in the USSR in 1964 NAMI developed the first so−called 4x4 agricultural truck NAMI 073 with a load of 4.5 tons and a gross weight of 9.6 tons on wide−length tires 1100x400x533 to work as part of a road train with a trailer with a gross weight of 6.5 tons.

In general, the structure of transport and technological support of agricultural production in Ukraine was quite rational, fit into the concept of agricultural cooperatives by M. Tugan−Baranovsky (which found its more effective implementation in market economies), but hasty dismantling of this system

(without building an updated) led to the stratification of the agricultural sector from actually medium−sized enterprises to small (individual−family and farm with small areas of land) and ultra−large (agricultural holdings with large areas of leased land).

This leads to a certain reorientation of the type of wheeled vehicles from agricultural medium−sized enterprises to 2 different areas of use:

−small agriculture (including small farms) with a dominant small wheeled machinery (tractors of traction class 0.6−1.4 tons and trucks with a load of 1−1.5 tons, trailers with a load of 1−1.5 tons);

−agro−holdings, dominated by wheeled tractors of traction class 3.0−5.0t (gross weight 10.3−16t, without attachments or trailers), which use three−axle trailers with a gross weight of up to 30t for transport operations (with a load of ball coupling of the tractor) with a trailer up to 3 tons) and general purpose road trains with a gross weight of up to 40 tons for main transportation of products from collection points in farms on paved roads to wholesale consumers, elevators, ports and others. The same wheeled tractors with trailers or remnants of the fleet of so−called multi−purpose all−wheel drive vehicles with trailers, mostly from Soviet times (MAZ, KAMAZ, URAL), are used for domestic technological transportation.

The relevance of all−wheel drive low−tonnage truck, in fact N1category (gross weight up to 3.5 tons) for individual farms and farms that grow products for sale, and obviously known in practice in the EU and Russia, where in addition to existing all−wheel drive UAZ, GAZ Gazelle / Sobol has developed and started production of low−tonnage universal trucks and tractors with a capacity of 0.3−0.8 tons (gross weight 1.7 tons − 3.2 tons) − NAMI 1337/1338/2238, which in the range of gear ratios are capable, except for transport , use the main functions of a mini−tractor for tillage and plant care, ie the segment of ultralight Unimog, Fig.2 It should be noted that this practice of small universal wheeled machines for small farms is common in Italy, France, Austria, Japan, Canada, where there are more than a dozen productions of this equipment and that would be suitable for the scope of the Kharkiv plant of tractor self−propelled machines.

Undoubtedly, these low−capacity wheeled vehicles are not of concern in terms of specific pressure and soil compaction, ie in terms of agri-environment, and the main problem is the support of the state and banking institutions to organize the development and production of wheeled vehicles.

However, in light of the intensive growth of the total area of agricultural land and sales of large agricultural holdings, the problem of relevant transportation is not only the well−known congestion of road trains with asphalt−paved roads, but also a much more serious problem of excessive compaction of fertile lands, their degradation as the basis of the agrarian economy.

Today in Ukraine, tractor trains dominate in large agricultural holdings on domestic transportation. According to (Rebrov *et. al* 2018), the distances of domestic traffic are in the range of 5−15 km (in Germany − up to 16 km), occasionally with the share of paved roads. At the same time, according to the experience of the EU countries, road transport, which accounts for up to 60−70% of the volume of transport work, is preserved in these transportations in medium and large agricultural holdings and enterprises. The reason for this is shown in the relevant studies, there is a significantly higher efficiency and lower costs compared to tractor transport, in particular, on the example of tests of a Fendt 933 wheeled tractor with a three−axle trailer (technical data − Table 1) and a road train − a 4x4 MB Zetros 1833 tractor and a three−axle SGT semi−trailer, Fig. 2.

Figure 1. Tractor Fendt 933 + SGT 30.

Figure 2. MB Zectros 1833 +SGT 32.

Basic technical parameters of typical wheeled road trains on domestic transportation in the agricultural sector (Rebrov *et. al* 2018).

Purpose of research

The purpose of the study is to determine agricultural transport − the type and structure formation of wheeled vehicles fleet.

Research results and discussion

At the same time, the maximum (and legally

permitted) speed of a Fendt tractor with a trailer is 60 km / h, and the maximum speed of the MB Zectros road train was limited to the same value (this allows you to work in Germany according to the law: on Saturday and Sunday). The volume of domestic traffic (from the field to the collection point) was 27.8 km, of which 15.6 km − the field, dirt roads and rural streets with paved roads in need of repair (section 1), and 12.2 km sections of the asphalt road of local importance (approximately II category according to Building Code).

Both road trains were loaded up to the permissible 40 t of total weight (ie MB Zectros road train carried 2.5 t more cargo due to lower equipment weight). The tire pressure is regulated according to the manufacturer's regulations for such transport work, ie 1.4 / 1.9 bar of the front / rear tires of the tractor and 2.5 / 3.2 bar of the respective vehicle. The tire pressure of the trailer or semi−trailer is the same 3.0 bar. In addition to the fuel speed characteristics, the vert acceleration in the driver's seat as an indicator of the specific working conditions of drivers was also indicated.

Fig. 3 presents the absolute values obtained during the comparative experiment for both the above and transportation in general, and in Table 2 − the corresponding specific ratios of indicators.

At the same time, according to the experimental data, we also assessed the fuel efficiency in terms of absolute costs in the usual linear costs for tractors (l / h) and trucks (l / 100 km).

Table 1. Technical data

Name	Power kW (hp)	Equipped weight, t	Tires, size (front / rear)	Trailer, equipped weight, t	Cargo volume of platform, m^3	Total weight of the trailer, t	incl. on the coupling device, t
Fendt 933 +SGT 30	$\frac{243}{330}$	10.76	$\frac{650/65R34}{710/75R42}$	10.5	56.0	30.0	3.0
MB Zect-ros 1833+ SGT 32	$\frac{240}{326}$	8.1	$\frac{560/60R22,5}{600/50R22,5}$	10.0	56.0	32.0	8.0

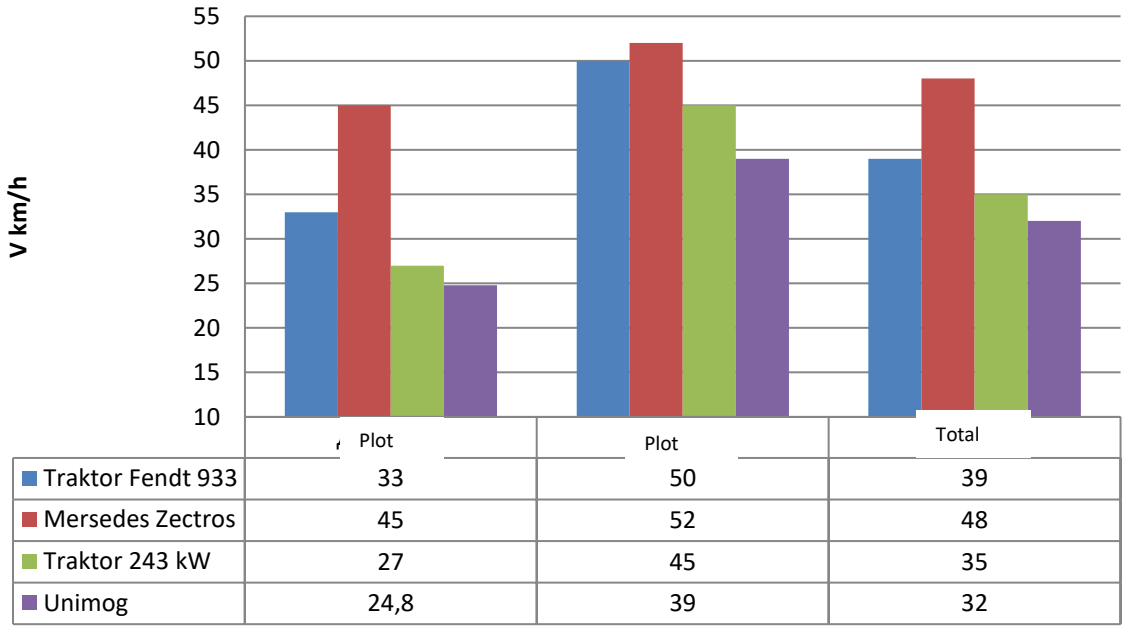
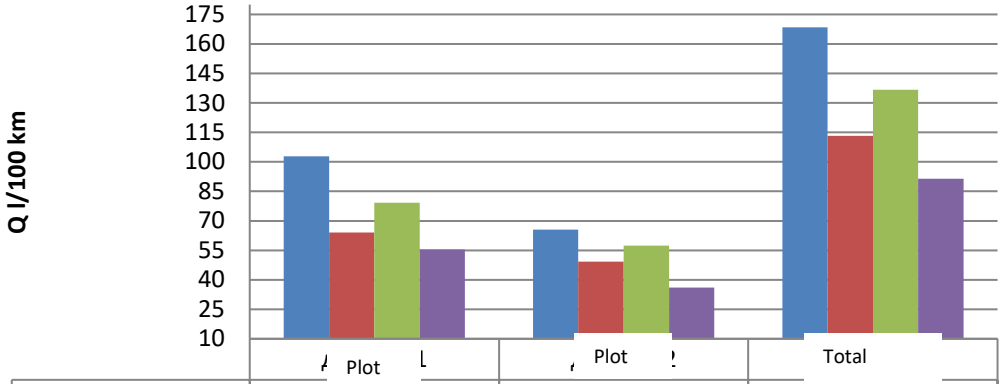


Figure 3. Average speeds of technological transport by trucks and wheeled tractors according

Table 2. Comparative assessment of fuel and speed characteristics and vibration loads, comfort of working conditions of the tractor driver and automobile road trains on domestic transportation (according to the results of the analysis)

	Average speed, %			Fuel consumption, % (l/h / l/100km)			Vibration loads of the driver %		
Section of the road	1	2	total	1	2	total	1	2	total
Tractor Fendt	100	100	100	100	100	100	100	70	85
Auto MB Zectros	134	100	123	60,2	75	66	60	50	55



	Plot	Plot	Total
Traktor Fendt 933	102,8	65,57	168,37
Mercedes Zetros	64	49,2	113,2
Traktor 243 kW	79,2	57,4	136,6
Unimog	55,4	36	91,4

Figure 3. Linear fuel consumption Q of automobile and tractor road trains on domestic agricultural transportation (according to data (Rebrov, 2017)).

Comparative analysis of the results shows the undeniable advantage and obvious efficiency of the use on domestic road in agricultural production of specialized road trains, providing 23−34% higher average speed and productivity while reducing fuel consumption by 39−34% and 34−40% reduction vibration loads on the human body (note that the permitted movement at a speed of 60 km / h on the local highway, as was accepted in this comparative study is not typical for wheeled tractors with trailers); tractors operated in Ukraine are limited to 40 km / h, which gives an additional advantage to a specialized road train).

Practically similar results for comparable transportation options were obtained in the study of the 243 kW tractor and the 310 kW MB truck in the study of the Department of Agricultural Engineering of the Technical University of Munich, the corresponding data are presented in Figures 3 and 4. At the same time, in addition to the above, we investigated 2 more transport options − with a tractor with a capacity of 121 kW (almost analogous to the T−150k) and a truck − Unimog with a capacity of 210 kW. The obtained results showed a significant reduction in fuel consumption of the tractor with a capacity of 121 kW (compared to a tractor with 243 kW) − an average of 10−12 l / 100 km (with a slight decrease in average speeds by 3−5.5 km/h). However, the efficiency of the universal Unimog with a trailer or semi−trailer deserves more attention, where average speeds and fuel consumption are almost comparable to all−wheel drive trucks larger than 100 kW power (at identical load capacity). It is obvious that qualitative co−refinement of the obtained results on all obtained combinations of technological transport of smaller tonnage is undoubtedly needed. It should also be noted, taking into consideration the seasonality of agricultural production, a much higher utilization rate of the actual type of Unimog tractor, which due to the existing 3−diagonal transfer case in the transmission, is used in agriculture and for cultivation of agricultural land (as a wheeled tractor).

Understanding the production capacity in Ukraine (KRAZ, overloaded production in the field of transport engineering), we can see the obvious feasibility of developing and commercializing the actual specialized trucks 4x4 and related trailers for the agricultural sector of the economy in 2 classes:

−category N1 with a gross weight of up to 3.5 tons of semi−rope layout with uneven distribution of loads on the front and rear axles in terms of off−road.

− category N3, with priority as a dump truck with three−way drive unloading and work as part of the trailer road train, as well as… .

− appropriate trailed equipment − uniaxial category 02 with a brake system of inertial pressure and two−three−axle, respectively, trailers and semi−trailers according to the scheme of so−called convergence of axles with pneumatic brake.

From the conditions of realities of domestic production, the restored model of the tractor of categories N3 both for a road train, and trailer (with the extended wheel base) can be created on the basis of all−wheel drive model KrAZ−5233 4x4 model equipped with the centralized system of regulation of air pressure in tires which is urgently necessary from the point of view of the conditions of agro−ecology and passability.

Actually, from the conditions of agro−ecology, it is expedient to process and produce wide−size tires of dimension 560/60 R22.5 or 600/50 R22.5. The same tires are wider for both tractor (in the T−150K version) and automobile three−axle trailers with a load on the axle load of 8−8.5 tons and a semi−trailer, taking into account the realities of high−speed N3 heavy road trains on roads and off−road local traffic as a power of the N3 tractor unit which is sufficient to use of the Dentz diesel engine unified with T−150 with a displacement of 7.7 l of RF6MHB / 2013 series (200−220 kW), which will

positively affect fuel economy and simplify repair service when using T−150K for tillage. Development and organization of production of large−scale three−axle agricultural trailers and semi−trailers real for domestic machine−building plants, subject to appropriate support from relevant state institutions, including the actual discount rate of the project within 5−7% per annum (if the government wants to keep potential).

In practice, the above is also relevant for the problem of farm vehicles of category N1 / N2. Taking into account the level of profitability of their activities, the prospect of importing such equipment from Germany (MB−V 80−110 thousand euros), France or Italy looks illusory. On the other hand, the development of the actual farming system in the agricultural spectrum without the appropriate technical support is simply illusory.

Conclusions

Technological transport in the agricultural sector of Ukraine is actually at the stage of formation. In fact, it is important to form a rational type for two uses − in small farms and large agricultural holdings. If the latter is realistic to use (with appropriate adaptation of structures) appropriate modifications of existing models of domestic HTZ and KRAZ (including in terms of import substitution), then for small farms (including in terms of pricing compared to imports) it is important to deploy low−capacity wheeled vehicles in Ukraine. From the European experience (after all, taking into account post−Soviet Russia) rational in this segment is the actual design of a universal low−tonnage machine type Unimog, which includes both the functions of a wheeled tractor class 0.6−0.8t, and all−wheel drive truck with onboard platform at 1−1.5 t.

References

Atramentova L. O., Utevskaya O. M. 2008. Statistical methods in biology. Horlivka: Lichtar Publishing House, 248 p.

Ignatov V. D. Organization of transportation of goods in the collective farms of state farms. M.: Rosselkhozizdat, 1978. 206 p.

Elisaev V. G., Labodaev V. D., Chernomorets N. A. Transport in agriculture. Minsk, Uradzhai, 1984. 151 p.

Belling Sohne WDr Bodendruck sohverer Ackerschlepper Fahrzeuge. Landtechnick, 1982. H.2. S. 16−24

DIN 19688 (2000) Bodenbeschaffenheit − Ermittlung der Verdichtungsempfindlichkeit von mineralischen Unterböden aus der Schätzung der Vorbelastung./ Deutsches Institut der Normung.

Gisi U., Schenker R, Schulin R. Bodeneokologie.−2 Au1l. Stuttgart, Thienna Verlag, 1997. 328 s.

Bernhardt H. Landwirtschaftliche Transporte . Wo stehen wir und was sind die Herausforderungen. TU München, 2014. 405 https://www.alb−bayern.de/media/files/0001/bernhardt−landwirtschaftliche−transporte.pdf.

Völkl L. K. W. Mercedes Zetros 1883 versus Traktor Fendt 933 / Fachhochschule Suedwesttalen. Soest, 2011. 219.

Ipatov A. A., Dzotsenidze T. D. Creation of new means of transport infrastructure development. Problems and Solutions. Moscow, Metallurgy Publishing House, 2008. 272 s.

Rebrov O. Yu. 2018. Distribution of allowable pressure on the ground of running systems of wheeled tractors on the territory of Ukraine. *Bulletin of NTU KhPI; Series mathematical modeling in engineering and technology*, Kharkiv № 27 (1303), p.110−116.

Rebrov O. Yu. 2017. Analysis of compliance of the maximum pressure on the soil of a tractor tire with agro−ecological requirements by the probabilistic method taking into account the soil and climatic conditions of Ukraine. *Bulletin of NTU*; *Series − Transport Engineering*: Kharkiv, № 14 (1236), 2017 P. 110−116.

The first "farmer" NAMI. Creation of an off−road utility vehicle NAMI − 072 / electron, resource. Access mode: http: / www.osnovnyje−srehstva|article.

DSTU 4521: 2006 Mobile agricultural machinery. Norms of action of running systems on the ground / Kyiv, Ukr NDNC; 2006. 8 p.