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Scientific And Technical Solutions To Increase The Life Of Pneumatic Tires Of The Unit

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Article History	*Abstract*
Received: 24 November 2023 Revised: 12 December 2023 Accepted: 27 December 2023	*This article examines the scientific and technical problems of increasing the working life of the tire part of a walking system of agricultural implements, and also makes an attempt to clarify information about reducing the rate of abrasion of the tire tread.*
CC License CC-BY-NC-SA 4.0	***Keywords***: *Unit, scientific and technical, tire, wheel, agriculture, crops, processing, tractor, complex, operation.*

1. Introduction

One of the main tasks of modern agricultural production is to increase production volumes based on comprehensive mechanization of all processes.
To accomplish these tasks, it is necessary to equip agricultural production with machines of the highest possible productivity, with high reliability and durability during operation.
Currently, there is a system of machines to perform all the work of cultivating and harvesting cotton, and it is also being developed in the future, where almost all work is entrusted to the shoulders of row-crop tractors with a complex of agricultural machines. A row-crop tractor, as a mobile machine, operates under various loads, both in terms of load capacity and traction. The main operational and agrotechnical qualities of a row-crop tractor are characterized by the capabilities of their drive wheels, in particular their tires. Pneumatic tires are manufactured for tractors and agricultural machines in accordance with GOST 7463-2003 [1, 2, 3, 4].
They must be selected based on the performance of agricultural machines with which mobile energy works, and a number of requirements for the cultivation of each crop. As is known, the characteristics of driving wheel tires are substantiated on the basis of comprehensive studies of their performance, taking into account the specific conditions of each zone. Consequently, tires of driving wheels must be justified by their operational and agrotechnical indicators, i.e., the selected tire must provide the necessary traction and grip while meeting the necessary agrotechnical requirements [5, 6, 7].
Conducted studies show [8,9] that slippage values increase rolling resistance and energy consumption in the system of technologies and machines for cultivating agricultural crops. Increased slipping and energy consumption occur when starting and accelerating the tractor unit, which leads to critical speeds of the tractor drive wheels.
In the system of machines for cultivating and harvesting cotton, the main power source is row-crop tractors of the 1.4 and 3.0 t class, and the most established width is 0.6- and 0.9-meter row spacing. Tractors are equipped with front wheel tires 12-16 L-163; 14.9R24 8PR. Rear wheels: narrow series model 9.5-42 YA-183, medium

series model 13.6 R38 YAR-318, 15.5-38 YA-166 and wide series model 18.4/15-30 R-319; 18.4 R34 TR-135 10PR (Table 1). In the future, the machine system includes the use of wide-cut agricultural machines [10, 11, 12, 13, 14, 15].
Taking into account the current situation in the use of drive wheel tires and the above stated requirements for tires, as well as the creation of new agricultural machines in the future, the purpose of our research is to study a set of operational and agrotechnical indicators of tractor drive wheel tires and, based on the research results, justify the tire model.
Studies of the compliance of the drive wheels of a row-crop tractor with the above requirements in the cotton-growing zone have not been carried out. It should be noted that many scientists have separately studied (investigated) the traction properties of drive wheels. The work of scientists is devoted to studying the process of interaction of the drive wheel with the soil [16, 17, 18, 19, 20].

Relevance and Relevance of the Topic Article
Currently, it is impossible to accept agricultural production without machine-tractor units (MTA). They are directly and effectively used by manufacturers and machine-building enterprises, which is one of the important tasks. "In the USA and Europe, the provision of branded technical services for agricultural machines is carried out by dealers of machine-building enterprises." Particular attention is paid to this system in countries that import technical equipment from foreign engineering companies, firms and enterprises.

All over the world, targeted research work is being carried out to increase the efficiency of using the technical equipment of MTAs, to fully utilize and maintain their operational condition during the warranty period, and to improve the processes of providing the technical condition of the MTA running system. Consequently, carrying out systematic scientific research aimed at increasing the efficiency of the running systems of the technical condition of the MTA by improving and justifying the parameters of the MTA wheel tires of modern agricultural machines on the basis of ensuring the performance of the machines during the period of their full use. Therefore, increasing the efficiency of the MTA by replacing the leading tractor wheel tires when performing technological operations is a very correct task [20, 21, 22, 23, 24].

After gaining independence of our Republic, much attention was paid to providing agricultural farms with highly efficient technical means and improving the quality of operational technical services. For example, in providing operational technical services to tractors and agricultural machines exported and manufactured by companies «Case», «New Holland» (USA) и «Claas» (Germany) regional service centers of joint ventures «Uzcaseservice» and «Uzclaasservice» certain results have been achieved. At the same time, it is necessary to improve a number of indicators of operational technical condition, such as speed, volume and quality of service by organizing the operational technical condition in the form of a system. Based on this, one of the most important tasks is to carry out comprehensive research work aimed at creating and improving regional structures for the provision of wheel tires and service centers for modern agricultural machinery.

Mass and Inertial Characteristics of Tractor Pneumatic Tires.
Metrological dimensions of universally cultivated wheeled tractor tires, standardized in standards, international reference books, recommendations and given in the manufacturer's catalogs. As a rule, the nominal values of the outer diameter and the maximum possible values of the profile width are given. [6,7]. For tire 12-16 L-163 installed in no more than 326 mm for the main rim W11/W8;8.00V and for permitted rims: W 9 - no more than 270 mm, W7 - no more than 254 mm. A number of regulatory documents standardize the value of the static radius $r_{ст}$, 12-16 L-163 tires rst = 400 mm. When changing materials in tire production, an increase in tolerance is allowed $r_{ст}$ on ± 2,5 %.

Our analyzes show that the tire sizes for the front or drive wheels of tractors, where it is clear that for the same tire section there are several rim width values, which is due to the presence of a range of relative size values and the requirement to set the rim width in whole inches (Fig. 1). But still, a tire of a certain model should be installed on a rim of the required width. In this case, you can get the best performance characteristics of the tire [25, 26, 27, 28].

a)

б)

Fig. 1. Determination of the rim width of the front wheels of the New Holland TD5 110 tractor:
a) front view; b) lateral view.

Changing the bead opening distance changes the cross-section of the tire and its characteristics (Fig. 2), which affects the operating condition of the tire. Thus, when installing a tire on a narrower rim, the radius of curvature of the treadmill decreases. As a result, the width of contact between the tire and the ground will decrease and, accordingly, traction force, and the wear rate in the central zone will increase.

When installing a pneumatic tire on a rim that is wider than the recommended width, the contact load will be concentrated on the outer shoulder areas of the treadmill, which will lead to increased wear in these areas and increased load on the material

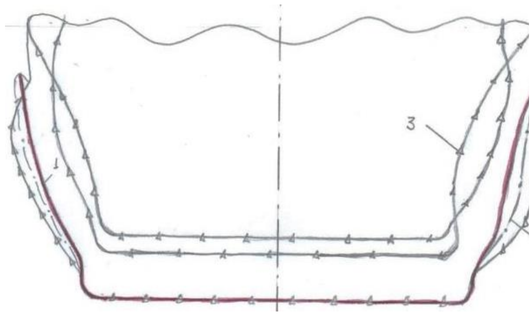

Fig. 2. Changing the profile of the 12-16 L-163 tire with devices when mounting it on W11/W8;8.00V rims:1-R_w=1,5 kgs/sm^2 (0,15 MPA); 2- P_w=0,9 kgs/sm^2 (0,09 MPA); 3- R_w=0,4 kgs/sm^2 (0,04 MPA).

When changing the tire profile, the weight of tractor tires in international standards and recommendations, as a rule, are not standardized or provided. The difficulty with standardizing mass indicators lies in significant changes in the mass characteristics of the tire materials themselves. Rubber density γ_p = 1,12-1,15 kg/sm^3, significantly changes the tire weight, saturation and depth of the tread pattern. As a result of testing the vibration method of a wheel with a tire on thread suspensions, the moments of inertia of cotton tractor wheels were obtained (table 1)

Moments of inertia of cotton wheeled tractors
Table 1

Tire designation (model)	Rim type according to GOST 10410	Wheel weight, kg	Moment of inertia of the wheel, Nм^2
12-16 L-163	W11/W8	85	103
9,5-42 YA-183	W8 DW8	150	394
13,6 R38 ЯР-318	W12; DW12 W11; DW11	155	448
14,9 R24 8PR	W13/W12	160	448
15,5-38 Я-166	W16L; DW16L	170	543
18,4/15-30 R-319	W14	250	809
18,4 R34 TR-135 10PR	DW18	240	809

By mathematical processing of experimental data, a relationship was established from which the torque can be calculated with an accuracy of 10% $I_к$ tractor wheels (N m) depending on their weight:
$I_к = 0{,}03m^2_{sh} = 0{,}264t_{sh}+9{,}57$,
where t_{sh}- weight of wheel with tire, kg.
The obtained dependence makes it possible to determine the change in the mass of cotton wheeled tractors.

Comparison of tire drive wheel models by load capacity.
Comparative indicators of the tractor drive wheel in terms of load capacity depend on many physical load factors [1, 16, 17, 18]. It is known that the tire 9,5-42 YA-183 between rows 0.6 m wide when performing inter-row processing of cotton, the tire works in a 20% overload zone 13,6R38 YAR–318- within the maximum permissible load capacity, and the tire 15,5-38 YA-166; 18,4/15-30 R-319 is underloaded. At row spacings of 0.9 m, the 9.5-42 tire is overloaded, and the tires 13,6R38 YAR-318; 15,5-38 YA-166 and 18.4/15-30 R-319 are underloaded. Thus, in terms of load capacity at row spacing of 0.6 m, the tires turned out to be acceptable 13,6R38 YAR-318; 15,5-38 YA-166 and 18,4/15-30 R-319. Tires were acceptable at row spacings of 0.9 m 13,6R38 YAR-318; 15,5-38 YA-166 and 18,4/15-30 R-319When comparing types of tires by traction indicators, we took as a basis the resistance of the cultivator during inter-row cultivation of cotton based on the SAMI protocol and the results of research carried out by SAIME. The traction force developed by each tire was taken from the results of experimental studies. The comparison results show that at 0.6 m wide cotton row spacing, the resistance of a 4-row cultivator is overcome by all studied tires with less than 15% slipping, and at 0.9 m row spacing, wide tires develop the required force within 17-19% slipping. The lowest slip value corresponded to the wide tire 18.4/15-30 R-319. Thus, in wide row spacing, when using 18.4/15-30 R-319 tires, there is a reserve traction force of about 140 N [28, 29, 30, 31, 32].

Economic Efficiency of Research Results
The optimal parameters of the tractor and its constituent elements are understood as those parameters, when combined, the selected efficiency criterion reaches a significant extreme. The solution to the problem of finding optimal tire parameters depends on the choice of this criterion. [33, 34, 35].
A comparative analysis of the results of assessing the efficiency of propulsors under various operating conditions showed the feasibility of installation on tractors MTZ-80X and New Holland TD5 110 tires 13,6R38 YAR-318 and 18,4/15-30 R-319. At the same time, the free diameter and normal stiffness of the tire 13,6R38 YAR-318, which corresponds to the maximum permissible internal air pressure, should be respectively in the range of 1.05-1.06 m and 180-120 kN/m.

Technical and economic indicators of implementation of the recommended model tractor wheel tires
Table 2

The name of indicators	Unit	Base option	Experienced option
Ground pressure	Mn/m^2	0,15-0,5	0,08-0,4
Slipping	%	3-4	2-3
Propulsion efficiency	G, (kN)	10	14
Average resource	%	80	86
Fuel consumption	кг	20	17

2. Conclusions

1. A decrease in the normal stiffness of a tire of a given model means an increase in its normal deflection, which leads to a decrease in service life. It has been established that to ensure normal tire operating conditions, the normal deflection must change in a certain range: (0.11-0.13) N - for tires with a diameter of less than 1.5 m and (0.15-0.2) N - for tires with a diameter of more than 1.5 m.
2. Compared to the bus, existing models 9,5-42 YA-183 tire recommended 13,6 R38 YAR-318 on 8-9%,15,5-38 YA-166 on 11-12% and tire 18,4/15-30 R-319 on 30-31%. When working on a tractor with a model tire 9,5-42 YA-183 at adhesion load G_n, equal to 1500 kg, and internal pressure R_w=0,18 Mn/m magnitude h = 0,0754 m. Under the same conditions with the tire 13,6R38 YAR-318 h=0,0693, and for 15,5-38 YA-166 h=0,0676. The smallest track depth corresponds to a tire 18.4/15-30 R-319, at internal pressure R_w = 0,18 Mn/ m^{2}h'=0,0578 m.
3. When using wider tires, the contact area increases sharply. Tire model 9,5-42 YA-183 at R_w =0,18 Mn/m^2 G_n=500 kg, the total contact area S is 0.027 m, and the tire 13,6 R38 YAR-318 reaches 0. 03847m. The same

observation when increasing tire width with 3,6 R38 YAR-318 before 18,4/15-30 R-319. In this case, when R_w=0,12 Mn/m $G_п$=2500 kg at the tire 13,6 R38 YAR-318 S=0,049718 m, and for the tire 18.4/15-30 R-319 S = 0.07236 m.

4. With maximum use of the load-carrying capacity of the proposed 18.4/15-30 R-319 tire, its area in contact with the soil reaches 0.0743 m, which is 2.15 times more compared to the 9.5-42 YA-183 tire.

5. Loads are observed on wide profile tires 18.4/15-30 R-319. This tire has a working Gn from 500 to 3000 kg R_w=0,12 Mn/m^2 the total area increases with 0,05558 before 0,07545m^2.

6. When a pneumatic tire rolls on a deformable base, the rut depth depends on the traction load applied to the wheel, internal pressure, and the size of the driving wheel and is in the range of 0.30-0.075. With an increase in the width of the drive wheel, the track depth decreases and for narrow profile tires it is 0.05-0.075 m, for the medium series it is 0.045-0.06 m and for wide tires it is 0.03-0.05 m;

7. The average value of the specific pressure exerted by a pneumatic tire on the soil when rolling between the rows of a cotton plant is within the limits of the tire series 0,16-0,58 Mn/m^2, middle series 0,15-0,5 Mn/m^2, for tires with series width 0,088-0,407 Mn/m^2.

8. The drift coefficient on a field prepared for sowing is on average 50-60% lower than on an asphalt road. With an increase in normal load from 4 to 10 kN, $K_{y\Sigma}$ increases by 48-73 %.

9. The 18.4/15-30 R-319 tire also turned out to be significantly weakly sensitive to changes in load: It should be noted that a similar difference in the amount of slippage is observed with increasing traction force P = 12753 N difference in the slippage of the wheel tire 9,5-42 YA-183 increases by 3-4 %, at the tires 13,6 R38 YAR-318 and 18,4/15-30 R-319 on 2-3%.

10. The data obtained show that within the permissible slipping values, the corresponding traction force increases. Due to the fact that acceptable slippage is taken to be б=20 %, then in further studies we took into account the magnitude of the traction force corresponding б=20 %.

11. It was determined that the track formed by the drive wheels against the background of cultivation is in the range of 0.03-0.075 m. For the narrow profile series, the track ranges from 0.05-0.07 m, for the medium series model 13,6R38 YAR-318 и 15,5-38 YA-1660,45-0,06 m and wide tires 0.03-0.05 m.

12. Analytical calculations have determined that the average value of the specific pressure exerted by the tires of the drive wheel on the soil is within the limits for a narrow series 0,16-0,58 MN/m, medium series 0.15-0.5 MN/m and for wide series tires 0.088-0.407 MN/m.

13. An experimental study has established that the tires of the middle series model 13,6R38 YAR-318 Compared to the narrow model 9.5-42 YA-183, they have 2-3% less slipping, and wide series tires have 4-5% less, which allows them to develop traction force that is 7-8% more than wide series and 13% more, respectively. more than narrow series tires. And the actual speed developed by medium and wide series tires is 9-10% and 16-18% higher, respectively, compared to narrow ones.

14. It has been proposed, based on the results of a comparison of a set of traction, traction and agrotechnical indicators, that it is possible to use tires up to 0.305 m wide in row spacing of 0.6 m, and tires with a width of 0.426 m in row spacing of 0.9 m.

15. Average resources of 15.5-38 YA-166 and 18.4/15-30 R-319 tractor tires, the probability of failure-free operation of the tire turned out to be equal to 86%, i.e., above the specified level of 80%.

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