Experimental research of agricultural bridge unit in the state of harrow aggregate

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Abstract. *From the standpoint of energy saving, the issue of research of agro-bridge units in the composition of new agricultural lands adapted to them is important and relevant tools that operate on the principles of track and bridge farming. One of the latter is a heavy tooth harrow with flat segments. Experimental determination of the characteristics of the agronomic bridge harrowing unit in its composition, in order to establish compliance of its parameters with the basic principles of the effective implementation of track and bridge farming, was adopted as a research objective. Experimental research was carried out both according to generally accepted and developed methods, and provided for the use of modern strain gauge and control equipment with analog-digital conversion of signals from information sensors. The processing of experimental data was carried out on a PC using probability theory, regression, and correlation-spectral analysis. Physical objects of researches were wide-track agricultural bridge construction vehicle TDATU with its track width of 3.5 m and harrowing machine (BZSS-1.0 type). According to the results of experimental tests of agricultural bridge harrowing unit as part of the dental harrow proved its good adaptability to work in the units of track and bridge farming and high quality of the technological process. The latter is also a consequence of the fact that the movement of the agricultural bridge is carried out on the compacted traces of a constant tramline, whose roughness profile is low-frequency in comparison with the longitudinal profile of the harrower. The constructive version of the tooth harrow is well reflected in the nature of its unevenness in traction resistance. It is established that the fluctuations of the harrow's traction resistance express a random function in which there are no harmonic components. The coefficient of variation of resistance fluctuations on the hook of the agricultural bridge during harrowing is no more than 10%. The latter indicates a high stability (low variability) of the process of harrowing the soil, has a positive impact on the stable movement of the agricultural bridge unit.*

KEY WORDS: *AGRICULTURAL BRIDGE MEANS, TOOTHED HARROW, EXPERIMENTAL TESTS, PROFILE OF AGROPHONE IRREGULARITIES.*

1. Introduction

Further highly efficient development of agricultural production in any country is possible with the widespread implementation of scientific and technological progress. These include the organization of field mechanized work on the principles of track and bridge systems of agriculture [1-5]. At the same time, the issues of finding new tillage implements, machines and implements for their effective use in track and bridge systems of agriculture are becoming important. Some of the representatives of the latter include a toothed harrow, made on the type of harrow "Nadikty-Ayubov" [6]. The functionality of the latter can provide loosening of the surface layer of the soil to a fine state without the removal of the wet layer on the surface, the stability of the harrow at depth, loosening and high quality tillage.

2. Preconditions and means for resolving the problem

Analysis of recent research. Such scientists as Nadykto VT, Uleksin VO, Kyurchev VM made a significant contribution to the development and popularization of track and bridge agriculture. and other. However, the analysis of the research results published by them showed [7,8] that it is not enough to work out the issue of experimental studies of wide-track agricultural bridge tillage units.

Regarding the use of the latter with adapted working bodies, the harrow with teeth with flat-cutting segments is of interest [9]. Segments of all rows on it are installed in the horizontal plane and at the same angle. But the use of this harrow construction does not allow effective destruction of weeds (weeds are wound on the working bodies). Also, the deepening of the working bodies of this tool into the soil is insufficient for its quality cultivation.

Known construction of the harrow "Nadykty-Ayubov" [6]. In it in the longitudinal-vertical plane the flat-cutting segments of the first row, and the second - at a bigger angle of inclination to horizon, than segments of the last rows are established. Such constructive execution provides, according to the authors of the development, high quality of tillage and is attractive for use in the composition of wide-track agricultural bridge units, which move in the footsteps of a constant technological track.

The purpose of the article. Experimental determination of the characteristics of the agricultural bridge harrowing unit in order to establish compliance of its parameters with the basic principles of effective implementation of track and bridge agriculture.

Research methodology. Experimental studies were conducted according to both conventional and developed methods and involved the use of modern strain gauge and control and measuring equipment with analog-to-digital conversion of signals from information sensors. The experimental data were processed on a PC using probability theory, regression, and correlation-spectral analyzes.

In the process of performing the experiments it was assumed: to determine the longitudinal profile of the irregularities of the traces of the constant technological track and the irregularities of the agro background before and after harrowing, soil moisture and density, depth of cultivation.

The physical objects of research were a wide-track agricultural bridge tool with a track width of 3.5 m and harrowing tools (type BZSS-1.0) (Fig. 1). The specified agro-bridge means used tires of wheels of the size 9,5R32. A specially equipped laboratory for its testing, which is located on the territory of TSATU, was used for research.

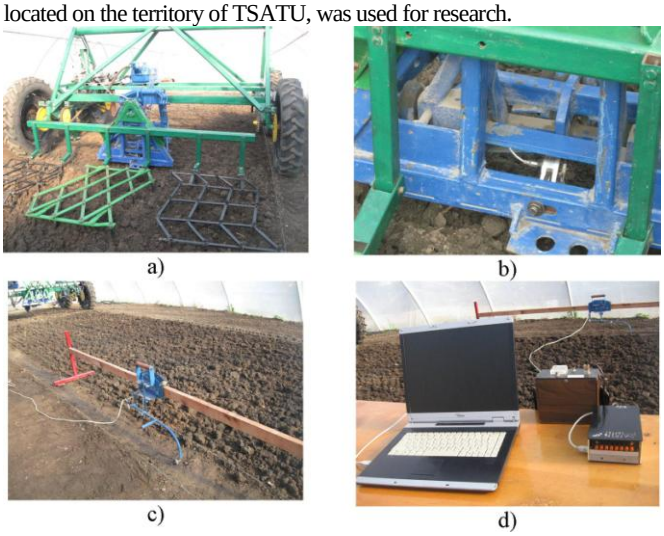

Fig. 1. *The studied agricultural bridge harrowing unit (a); dynamometer (b); automated profilograph (c); analog-to-digital converter (ADC) and PC (d)*

To register some of the measured parameters, such as unevenness of the profile of the agricultural background, the traction resistance of harrowing tools, we used a measuring and

recording system based on analog-to-digital converter (ADC) and personal computer (PC) (see Fig. 1).

Obtained in the process of experimental research implementation in the form of digitized data was transferred to the software environment Microsoft Excel. It calculated such statistical characteristics as: average value; standard deviation (standard); dispersion; coefficient of variation; sampling average error; normalized correlation function; normalized spectral density. These statistical parameters were determined by methods [10-12]. The error of direct measurement of parameters did not exceed 1%.

Soil moisture was determined by a standardized thermostatic-weight method. The depth of cultivation in the research process was measured with a specially designed depth gauge in 10 places on the diagonal of the treated area.

Experimental tests of the agro-bridge harrowing unit were carried out on the control and test section with a length of 50 m of the mentioned laboratory. The speed of operation of the agro-bridge unit was 3.6-4.5 km·h^{-1}.

3. Results and discussion

During the research, the average value of soil moisture in the layer of 0…10 cm was 26.8%, and the density was 1.23 g·cm^{-3}.

Analysis of the obtained experimental data showed that the profile of the constant technological track is significantly smoothed in comparison with the profile of the treated agricultural background. Thus, if the standard deviation of the profile of the harrowed agricultural background is ± 1.36 cm, then for the track profile this figure is ± 0.84 cm, ie 1.6 times less (Fig. 2).

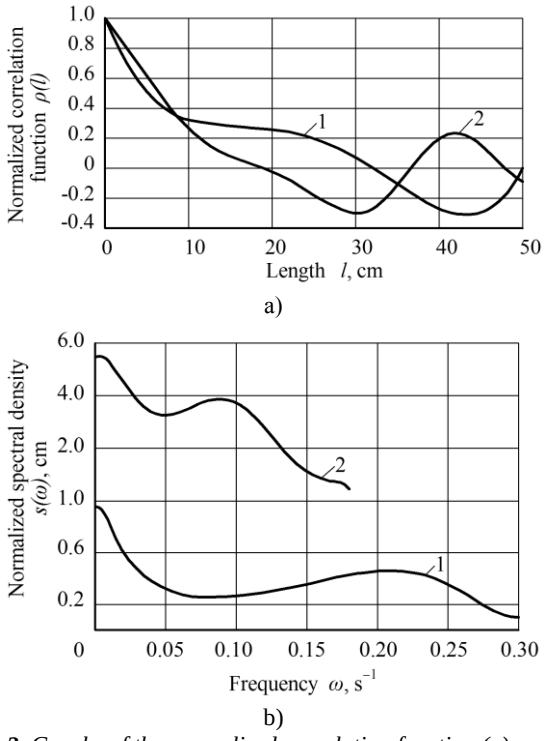

Fig. 2. *Graphs of the normalized correlation function (a) and the spectral density (b) of the inequalities of the longitudinal profile of the traces of the constant technological track (1) and the harrowed agricultural background (2)*

According to their internal structure, the inequalities of the profile of traces of a constant technological track are characterized by a function that contains, along with random components - harmonic, which are expressed by attenuating periodic oscillations of the normalized correlation function, which is presented in Fig. 2a. The length of the correlation of the ordinates of the irregularities of the profile of the traces of the constant technological track is about 0.18 m, which corresponds to the pitch of the ground on the tires of the agro-bridge means, the value of which is equal to 0.175 m.

The spectrum of frequencies that make up the random function of the inequalities of the profile of the traces of the constant technological track determines the normalized spectral density of the ordinates of the mentioned inequalities of the profile (Fig. 2b). From the analysis of the normalized spectral density (see Fig. 2b) it was found that the cutoff frequency for this process is approximately 0.3 cm^{-1}. The main share of variances of oscillations irregularities of the profile of the technological track traces is concentrated in the frequency range 0…0.3 cm^{-1}. The standard deviation of the ordinates of these irregularities is consistent with the height of the ground hooks of the tires of the agricultural bridge means, the value of which was equal to 0.03 m.

The above analysis of the characteristics of the irregularities of the profile of the constant technological track on which repeatedly moves the agricultural bridge means shows that the generator of the formation of these irregularities are the parameters of the ground engagement of the tires of its wheels.

The internal structure of the oscillations of the longitudinal profile of the cultivated area of the agricultural background is slightly different from the structure of the irregularities of the profile of the traces of the constant technological track (see Fig. 2). The length of the correlation relationship of the ordinates of the irregularities of the harrowed agricultural background is about 2 times larger and is about 34 cm. This profile of the agricultural background is typical for a field prepared for sowing cultures.

In contrast to the unevenness of the profile of the traces of the constant technological track formed by the tires of the wheels of the agricultural bridge means, the profile of the harrowed section of the agricultural background has a lower frequency character (see Fig. 2b). From the analysis of the normalized spectral density it was found that the cutoff frequency for this process is 0.18 cm^{-1}. The main share of variances of oscillations inequalities of the processed agricultural background is concentrated in the range of frequencies 0…0.18 cm^{-1}.

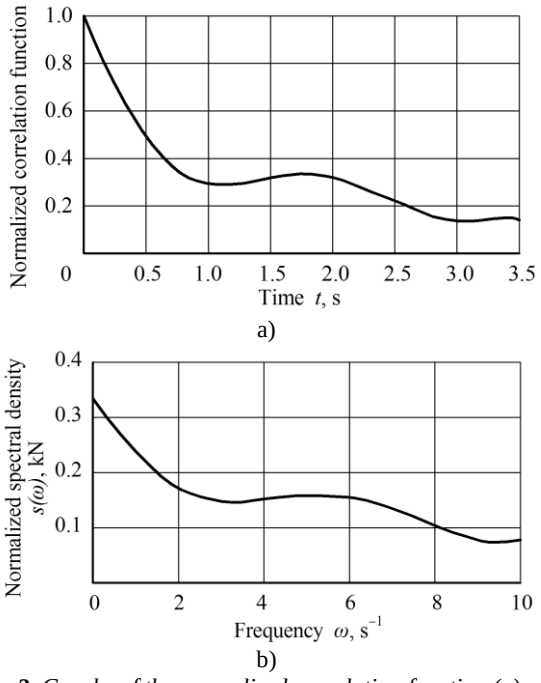

Fig. 3. *Graphs of the normalized correlation function (a) and spectral density (b) of oscillations of the traction resistance of the harrowing tool*

Fluctuations in the traction resistance of the harrowing tool express a random function in which there are no harmonic components (Fig. 3a). The main spectrum of dispersions of traction resistance oscillations is concentrated in the frequency range 0…3.5 s^{-1} (see Fig. 3a). According to its energy (Fig. 3b), the dispersion of the oscillations of the traction resistance of the studied harrow was 0.027 kN^2, and the standard deviation is 0.166 kN. With an average value of traction resistance of 1.71 kN of three harrows in the

bridge unit, the coefficient of variation of its (ie resistance) oscillations during harrowing is 9.76%. The latter is a desirable feature that indicates the high stability (low variability) of the process of harrowing the agricultural background agricultural bridge means in the harrow "Nadikty-Ayubov".

Indicators of soil harrowing quality corresponded to agricultural requirements related to this technological operation [13]. In particular, the deviation of the actual depth of cultivation from the set did not exceed ±1 cm, and the height of the ridges on the agricultural background was not more than 2 cm.

4. Conclusions

According to the results of experimental tests of the agricultural bridge harrowing unit, it is good adaptability to work in the units of track and bridge agriculture and high quality of the technological process have been proved. The latter is also a consequence of the fact that the movement of the bridge agricultural tool is carried out on the compacted traces of a constant technological track, the profile of the irregularities of which is low-frequency in comparison with the longitudinal profile of the harrowed agricultural background.

The structural design of the "Nadikto-Ayubov" dental harrow is well reflected in the nature of its uneven traction resistance. It is established that the fluctuations of the harrow's traction resistance express a random function, in which there are no harmonic components. The coefficient of variation of the resistance fluctuations on the hook of the agricultural bridge at harrowing is no more than 10%. The latter indicates high stability (low variability) of the process of harrowing the soil. And this reduces the unevenness of the moment of resistance on the engines of the agricultural bridge, which positively affects the stable movement of the agricultural bridge unit.

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