Assessment of machines in reliability test

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Summary: *The necessity of using the apparatus of mathematical statistics to obtain high reliability of the results of the evaluation of the reliability indicators of agricultural machinery in comparative tests is justified.*
Two models of plant protection machines have been tested and the main numerical characteristics of the indicator production till failure of the failure-free feature have been obtained.
The application of the Student's criterion for proving the statistical significance of the difference in the tested reliability indicator is justified.
Keywords*: machines, testing methodology, agricultural machinery, parameters, criteria, test plan, numerical characteristics, reliability, refusal*

When testing agricultural machinery for reliability, as well as for determining all quantitative and qualitative parameters, it is necessary to use the mathematical statistics apparatus. It is best suited for making science-based decisions when determining the best machine or machine model for a given parameter. For a reliable estimate, it is not sufficient to use only the estimate of the average value of the test parameter, since the parameter is a random variable. Statistical criteria should be used to determine the significance of the difference in the mean scores. There are two sets of criteria for proving the statistical significance of the difference: parametric and non-parametric criteria. The most applicable of the group of parametric criteria is the Student's criterion, and the group of nonparametric criteria is the Man-Whitney criterion, [2-5].

The purpose of the study is to compare two models of plant protection machines against the failure free operation of reliability indicator.
The test is carried out in accordance with the experimental testing methodology [1] according to the plan [N =! RT], where R-means a plan in which the failed objects are replaced with new or repaired ones, and the T-test is carried out until the moment T.
We choose this test plan because we cannot test a large number of sites. At one site / N = 1 / we perform the test up to the moment T / the determined number of hours or area / and when a failure is detected in the machine, it is removed and the test continues until the next failure and so until the moment T occurs.
Two models of plant protection machinery from different manufacturers are subject to testing, and the results of the reliability test are given in Table 1.

Table 1. *Numerical characteristics of the production-to-failure indicator of two models of plant protection machines*

Dependencies for determining numerical characteristics	plant protection machines	
	Brand/ Model 1	Brand/ Model 2
$\vec{X} = \sum_{i=1}^{n} X_i$	$\vec{X}_1 = 45{,}1$ h	$\vec{X}_2 = 62{,}8$ h
$S = \sqrt{\sum_{i=1}^{n} (X_i - \vec{X}) \Big/ (n-1)}$	$S_1 = 19{,}8$ h	$S_2 = 25{,}4$ h
n	$n_1 = 36$	$n_2 = 36$

Означения*:* $\vec{X}$ *– estimation of the average value of the measured parameter of the machine;* X_i *– the* i *th value of the parameter;* S_i *– estimation of the root mean square deviation of the machine parameter values;* n *– the number of machines tested or the measured values of the measured parameter of the machine.*

As a result of the testing of the two models of plant protection machines, we find that the production up to failure of model 2 is higher than that of model 1. Only on this numerical characteristic of the measured indicator of the reliability of the machines / production up to failure / cannot to decide: which of the two models of plant protection machines has a higher level of trouble-free operation. Therefore, we also determine the numerical characteristic - standard deviation and apply the Student's criterion for proving the statistical significance of the differences in the values of the average production up to failure of the two models of plant protection machines. Therefore, we are in the situation shown in Figure 1.

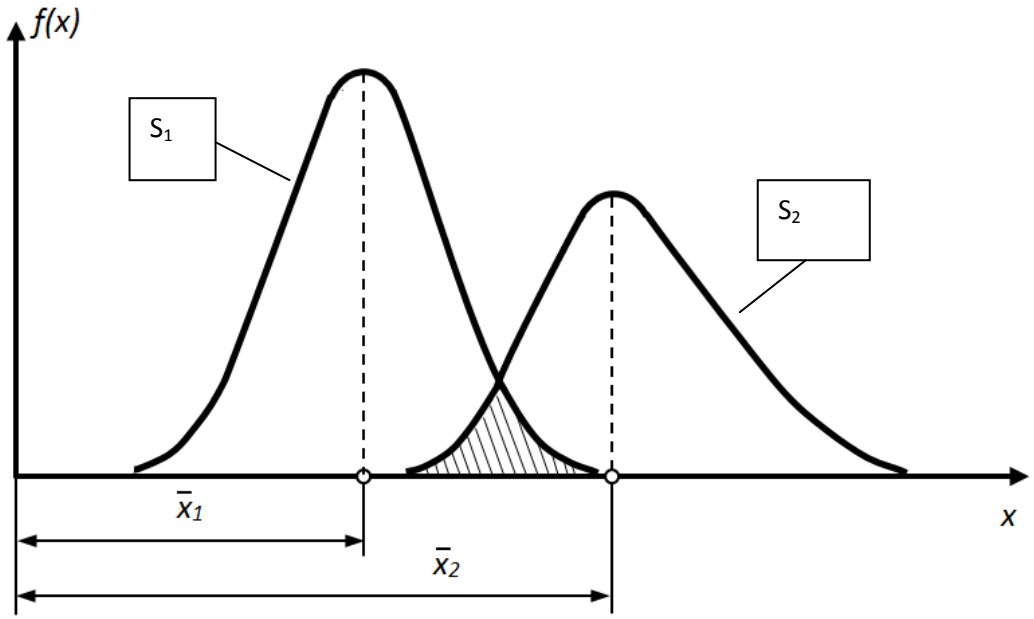

Figure 1: *Densities of the distribution of work until failure of the two models of plant protection machines tested*

In this situation / figure 1/, in order to decide which of the machines as a result of the reliability test has a better performance of the failure-to-build indicator, we have to apply the criterion for the statistical significance of the differences in the numerical characteristics of the performance-to-failure indicator.

The procedure for applying the Student test is as follows:

1.Determination of pooled dispersion:

$$D = \frac{1}{2}(S_1^2 + S_2^2) = 518{,}6$$

2. Determination of the calculated value of the Student's criterion for dependency:

$$t_{ИЗЧ} = \frac{\left|\overline{X}_1 - \vec{X}_2\right|}{\sqrt{\frac{D}{n_1} + \frac{D}{n_2}}} = 3{,}297 \approx 3{,}30$$

3. Determining the degrees of freedom and choosing the confidence probability for deciding on the statistical significance of the differences in the estimates of the reliability-to-failure indicator characteristic:

$$t_{табл} = t_{a;\nu} = ?$$

The degrees of freedom are determined by the dependence of: $\nu = 2(n-1) = 70;$

and the confidence probability is assumed $\alpha = 0{,}01$ or $\alpha = 0{,}05$. We also accept 0.01 in the table of values of the Student's criterion for $\alpha = 0{,}01$ and $\nu = 2(n-1) = 70;$

we report. $t_{0{,}01;70} = 2{,}618$.

From here, comparing the calculated value of the Student's criterion / 3.30 / with its tabular value / 2.618 / we find that 3.30> 2.618, therefore the differences in the estimation of the average value of the two models' production are statistically significant, ie. the plant protection machine model 2 has a higher performance of the failure-to-failure indicator, / figure 2/.

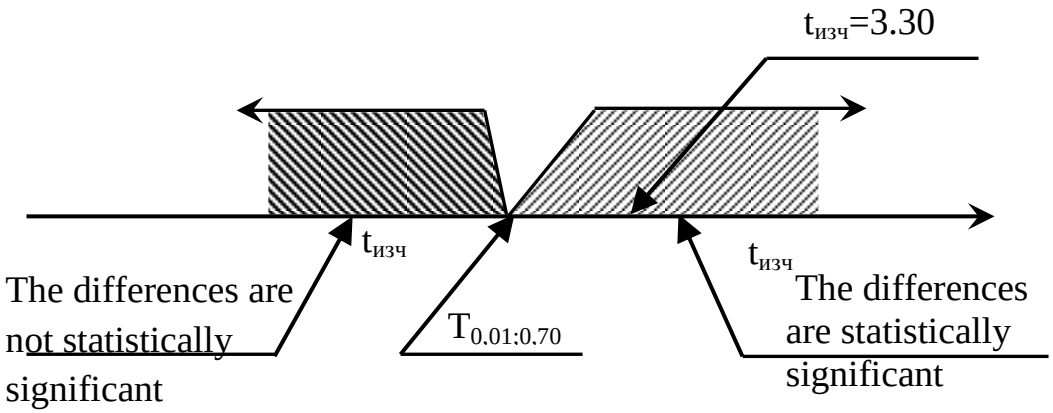

Figure 2: *Graphical representation of the essence of the Student's criterion for deciding the statistical significance of the tested machine parameters.*

Main conclusions:

1. Two models of plant protection machines have been tested and the main numerical characteristics of the indicator production till failure of the characteristic failure-free operation, have been determined .
2. The application of the Student's criterion for proving the statistical significance of the difference in the tested reliability indicator is justified.
3. It has been proven that the Model 2 machine is better in performance till failure than the Model 1 machine .

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