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Analysis Of Geometric Parameters The Keyed Joints' Details Of Grain Harvesters "Vector".

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ABSTRACT

The deviations in the dimensions of the parts of the interfaces coming in as spare parts to various trading companies of the Stavropol Territory are analyzed. Inaccurate manufacture of keyed spline joints leads to the fact that the key in the groove starts to warp, not evenly perceiving the forces that arise, and as a consequence, quickly wear out and crumple, damaging the grooves of the shaft and bushing. The micrometric tool used in the course of research is indicated, as well as a technique for determining the probabilities of obtaining joints with interference and clearance. To determine the quality of the production of keyed parts, they were sampled by a total of 50 pieces of each standard size. The main characteristic causes of failure of keyed connections in mechanical drives of combine harvesters are revealed. The measurement of the diametral dimensions of the coupling "shaft-bushing" showed the presence of rejection and during the assembly there is a clear possibility of forming a gap in this joint. From the studies of the geometric parameters of the details of keyed connections coming in as spare parts, it was revealed that the experimental values obtained are at the upper boundaries of the tolerance fields, which obviously causes a low connection resource. Theoretical and experimental dependences of the distribution of gaps and strains of the main interfaces of the combine harvester VECTOR 410 are obtained. Advanced methods of increasing the efficiency of harvesting equipment use and reducing its downtime due to the failure of keyed joints due to the use of the developed upgraded fixed connections are proposed. The description of the design features of the proposed technical solutions and practical recommendations for their application are presented.
Keywords: combine harvester, keyed connection, restoration, hub, shaft, landing.

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INTRODUCTION

Agricultural machinery requires high reliability in its operation, both in fieldwork and in the transportation of goods and passengers. This problem is most acute during harvesting of cereals, which is carried out in a tight agrotechnical time. The work of grain harvesting equipment is characterized by the fact that malfunctions and downtime in operation lead to huge financial losses [1].

It is common knowledge that the combine harvester is a complex technical system consisting of a large number of heterogeneous but interrelated components and parts: gearboxes, harvesting parts, bumper beater, threshing machine, grain augers, pulleys, sprockets, bearings, keys, pumps, conveyors, brakes, etc.

But in this case, this approach does not emphasize the features of the work of specific parts, which can have several working surfaces that are fundamentally different in their functional purpose. Accounting for this specificity, which we realize in practice, can significantly improve both the reliability of the machine itself and the efficiency of the technology in which it operates [2].

From the defect tables specified in special manuals, norms, and rules of manufacture and repair, it follows that in most cases certain operating restrictions have numerous pairs of friction of parts, in particular, keys, keyways working, as a rule, in difficult reverse conditions and falling of abrasive [3].

Inaccurate manufacture of keyed splines leads to the fact that the key in the groove begins to warp, not evenly perceiving the forces that arise, and as a consequence, quickly wear out and crumple, damaging the grooves of the shaft and bushing [4]. Therefore, in order to identify the causes of this type of failure, geometric parameters of the parts of keyed joints coming in as spare parts were analyzed.

MATERIALS AND METHODS

For research, the combine harvester VECTOR 410 was chosen, which became widespread in the farms of the Stavropol Territory.

In keyed joints of combine harvesters for diameters Ø 30 ... 65 mm, dowels with dimensions of 8 × 7 × 40, 12 × 8 × 40, 14 × 9 × 125 and 18 × 11 × 200 [4] are used. Parts in the keyed joints are simultaneously interfaced in three plantings: "shaft - hub", "shaft groove - key" and "hub groove - dowel". And in all three types of landings, the technical conditions of the manufacturer's factory provide a gap that directly affects the performance of the connection as a whole [5].

To study the properties of the working surfaces of the parts of keyed connections, the equipment and instruments of the innovation laboratory "Educational and Research-and-Production Center" Restoration and Strengthening of Machine Parts "of the Stavropol State Automobile Inspection were used.

Measurement of the width of the keys and the diameter of the shafts was carried out by the contact method with the help of electronic micrometers MKC-25, MKC-50 and MKC-75, respectively, with a reading accuracy of 0,001 mm, and keyways and internal diameters of pulleys using NOM-18 and NI-50 indicator indicators with the indicator head 1IG [8].

To determine the quality of the parts of the keyed connection, they were sampled with a total of 50 pieces of each type presented above.

The measurement of the diametral dimensions of the coupling "shaft-bush" showed the presence of rejection and during the assembly, there is a clear possibility of formation of a gap in the given joint (Fig. 1) [5].

It has been established by investigations that the scattering of gaps and strains obeys the law of normal distribution and the tolerance of parts is equal to the magnitude of the scattering field; $T=6\sigma_{pos}$.

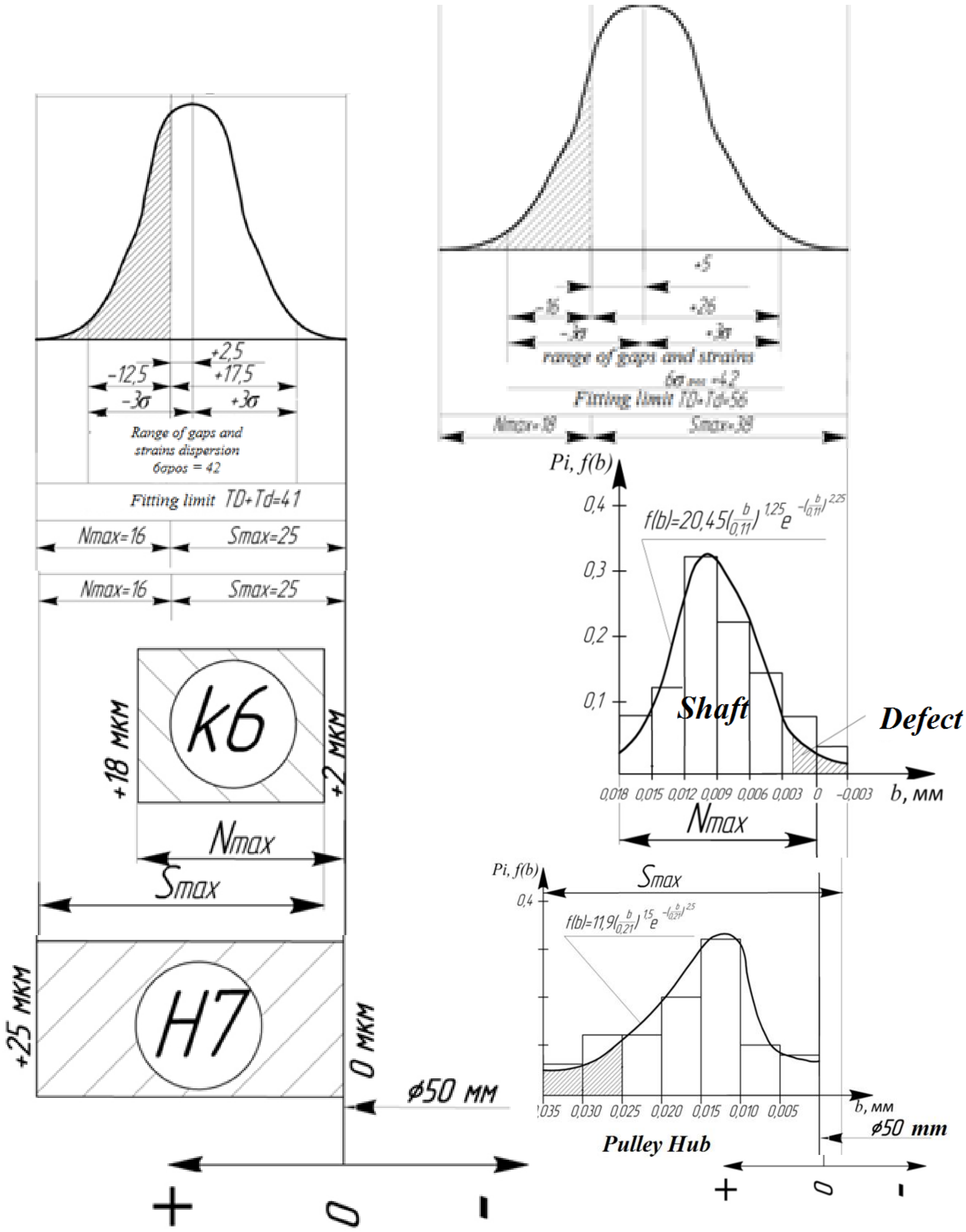

Figure 1: The probability of obtaining connections with interference and clearance in the coupling of the "shaft-hub of the pulley" Ø50 mm of the breaker beater of the combine "VECTOR 410":
a) theoretical; b) experimental, with a graphical construction of the experimental distribution

Taking into account the random nature of the assembly, the mean square deviation of landing σ_{pos} is determined by the formula:

$$\sigma_{pos} = \sqrt{\sigma_{hub} + \sigma_{shaft}}, \quad (1)$$

$$\sigma_{hub} = \frac{}{6}$$

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$\sigma_{hub} = \dfrac{T_D}{6}$ - the standard deviation of the diameter of the pulley hub, mm;

$\sigma_{\text{shaft}} = \dfrac{T_d}{6}$ – the mean square deviation of the shaft diameter, mm;

T_D and T_d – tolerances dimensions of the hub, pulley and shaft.

The probability of obtaining gaps and strains in the compound under consideration was determined by the normalized Laplace function from:

$$F_z = \frac{1}{\sqrt{2\pi}} \int_0^{z} \quad dz, \tag{2}$$

RESULTS AND DISCUSSION

The theoretical probability of obtaining gaps in the conjugation of the "shaft-bush" Ø50 of the breaker beater of the combine "VECTOR 410" (unshaded area along the distribution curve) is 69.1%, and the experimental gain obtained on the basis of the micrometer is 76.2%. In this case, the probabilistic interference is 30.9% and 23.8%, respectively. The experienced probabilistic interference of -16 µm and the +26 gap are almost limit. It should be noted the possibility of a marriage in this conjugation up to 12%.

Similarly, the situation with other types of landings. So, as an example, consider the "shaft-key groove" fitment used in the coupling of the rear counter drive "pulley RSM-10.01.34.060A and shaft 101.01.34.601" of combine harvester "VECTOR 410" (Fig. 2).

In this connection, landing is applied 12 N9/h9 $\left(\dfrac{-0{,}043}{-0{,}043}\right)$.

Analysis of conjugation of the "shaft-key groove" 12 mm of the rear counter-drive of the combine "VECTOR 410" showed that the theoretical probability of obtaining a gap and interference is 50%, whereas the experimental value differs significantly and is 91.31% and 8.69%, respectively.

From the studies of the geometrical parameters of the details of keyed joints acting as spare parts, it was revealed that the experimental values obtained are at the upper boundaries of the tolerance fields, which, of course, causes a low connection resource [4].

The structural arrangement of the mechanical drives of combine harvesters stipulates that the keyed connections are located at the output ends of the shafts, which is a prerequisite for dismantling, for example when replacing bearings. Therefore, the use of nanocomponent polymer compositions, ultra- and nanocomposite chemical nickel plating, and other technical solutions for obtaining interference fitings in these cases is not advisable [5].

In this regard, to increase the efficiency of the use of complex agricultural machines, reduce costs when operating them, increase the shift capacity and reduce grain losses during harvesting, it became necessary to modernize the fixed connections of combine harvesters.

In order to remove the cyclicity of the change in the speed of contacting the working surfaces of the key with the hub, we intend to "tighten" the details of the problem connection according to the "double swallowtail" principle. This design can be used in both fixed and mobile connections, for example, in the hub of the PCM.10.01.15.609A and in variators. But this connection has a number of design limitations - it can be implemented on the output shaft part. In addition, the proposed technical solution can only be realized at the manufacturing plants, the equipment of which can provide the required accuracy of the manufacture of key and keyway grooves and shafts [6].

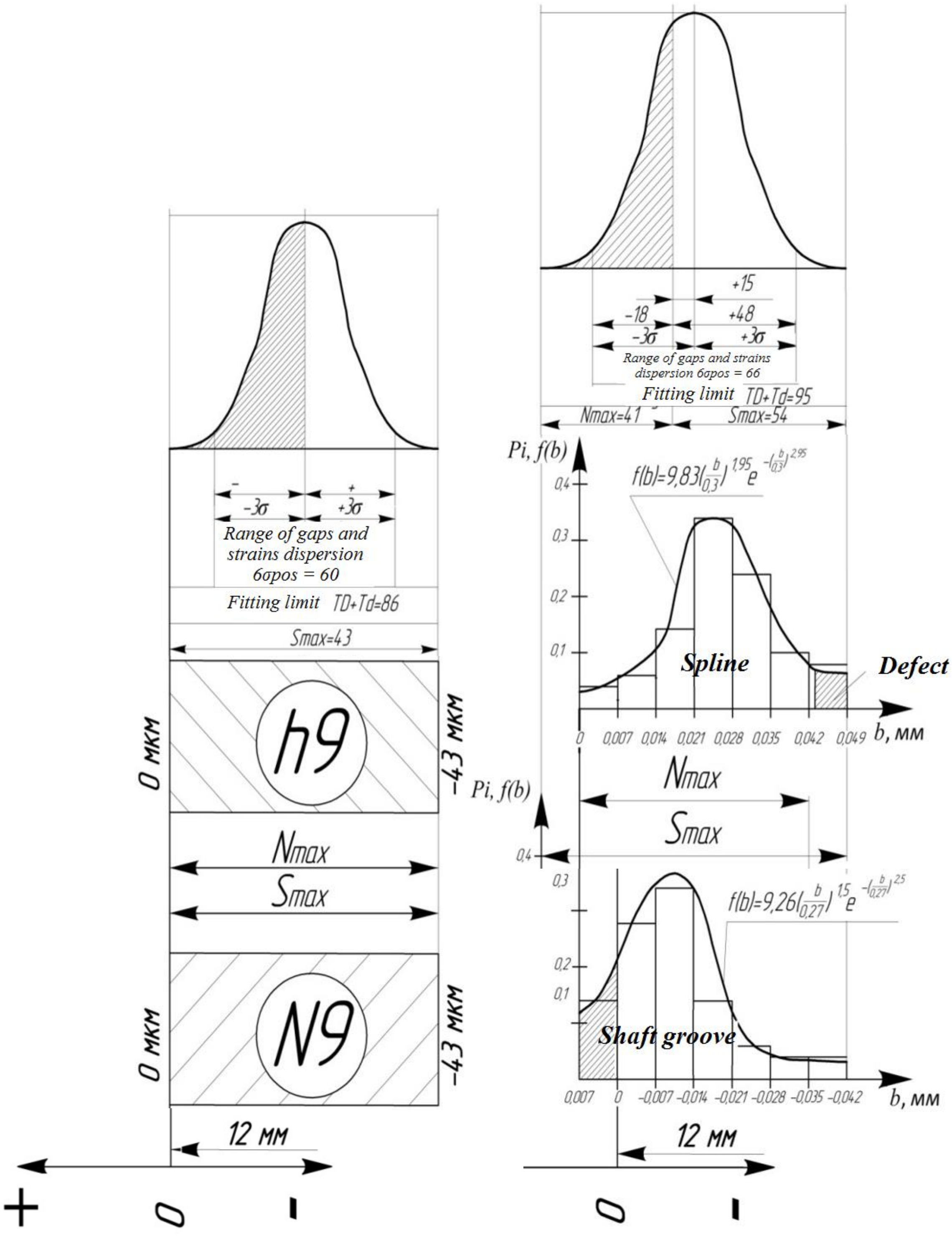

Figure 2: Probability of obtaining joints with interference and clearance in the interface "shaft-key groove" with a width of 12 mm rear counter-drive of the combine "VECTOR 410":
a) theoretical; b) experimental, with a graphical construction of the experimental distribution

Another effective solution is the installation instead of the existing keyed connections, where technical requirements permit, a removable hub for mounting the rotating element on the drive shaft, which can be made in the form of a repair kit with sufficient accuracy in the repair shops of the farms [7]. It should be noted that there are also some limitations on the installation of the proposed removable hub, which cannot be used in mobile connections. First of all, the repair kit should reduce the time of restoration of the operability of the connection.

As an effective technical solution for the method of connecting with the interference of parts, the shaft-bushing can serve, as developed by us, a "pseudo-bolt" connection, which implies the creation on the shaft of known solid sections in the form of rectangular sectors [8]. The assembly of the connection is carried out with an interference that allows the hard sectors of the shaft to be pressed into the mating surface of the sleeve, which forms a kind of "pseudo-link" connection. At the same time, the number of exploratory - assembly operations increase with a minimal change in the value of the actual interference in the connection.

CONCLUSION

Thus, new methodological approaches to improving the efficiency of technological processes, carried out theoretical and experimental studies have allowed us to apply new technical solutions to the modernization of keyed connections that ensure an increase in their durability and reduce the time for eliminating the failure of mechanical drives of combine harvesters of domestic and imported production.

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