Quality assessment of spare parts for the final drive reduction gear used in the MTZ-82.1 tractors

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Abstract. The main machine repair problem and the main hidden defects are determined. The analysis of the protocols of the machine test stations showed that the greatest number of tractor failures occurs in the final drive gearboxes. To study their quality, such spare parts as the shaft, front axle half-shaft and the gear were selected. The main physical, mechanical and geometric parameters of the investigated spare parts, necessity and reasons for high quality control for qualitative production of spare parts are considered. Controlled geometric defects, methods and means of control of transmission spare parts are determined. Means of measurement for comparison of indicators and control accuracy are proposed.

1. Introduction

The problems of controlling the parameters of spare parts are an urgent task to ensure the machine repair quality. A special role in the introduction of defects during the machine operation is played by hidden defects that are not detected during assembly - these are defects due to non-compliance with the standards of interchangeability of critical parts both in clearance fits [1] and interference fits [2] and defects from using poor quality spare parts, for example - seals [3], when serious oil leaks occur during operating the units. Due to the low accuracy of parts in repair production, it is necessary to use methods of incomplete interchangeability [4], which leads to increased costs. Weak metrological support for the production of repair enterprises [5] and measurement errors of devices at the stages of input, production and acceptance control also contribute to losses during control [6].

Analyzing the protocols of machine-testing stations and the list of failures and damages of agricultural machines for the period of their testing [7, 8, 10], it was reported that the largest number of tractor failures occurs in the final drive gearboxes. Constructive defects in the manufacture of parts are the main causes of failure.

As the analysis shows, the parts of the final drive gearbox of the MTZ-82.1 tractor most often failed: the front axle shaft 52-2308063; front axle half-shaft 52-2308065; gear 52-2308061. These parts are the most loaded and difficult to manufacture. The reason for the failure of such parts is the inconsistency between the physical, mechanical and geometric parameters.

2. Analysis, causes and means of control

Due to the inconsistency with the physical and mechanical parameters, microcracks are formed, which during operation leads to the destruction of the product.

Due to the inconsistency with the geometric parameters of the spline joints of shaft-type parts, the splines wear out quickly. Therefore, the part will fail quickly during its operation what entails additional costs for its replacement.

For various reasons, parts fail and need to be quickly replaced with spare parts, which in turn also do not always meet their established requirements. However, it should be considered that a significant number of low-quality spare parts are fake or counterfeit. Various sources estimate counterfeit spare parts supplied for sale from 9 to 30% of total sales, depending on the type of spare parts [9].

All these reasons are the need for high control of all parameters related to the quality of spare parts.

Based on the above, 3 types of spare parts were selected for further research (front axle shaft 52-2308063; front axle half shaft 52-2308065; gear 52-2308061); the controlled parameters are their geometric dimensions and physical and mechanical properties.

The main geometric defects, methods and means of control of the investigated spare parts have been determined (table 1) [10].

Table 1 shows that the nature of the controlled geometric parameters is similar to each other.

Table 1. Controlled geometric defects, methods and means of control of spare parts of transmission groups.

Defect No. in the picture	Name of the controlled defect	Dimension, mm		Methods and means of control		
		According to drawing	Allowable	Name	Identification	Measurement error, mm
1	2	3	4	5	6	7
Front axle half shaft 52-2308065 (figure 1)						
1	Tooth wear by thickness	The length of the common normal is checked at three locations at approximately 120 °. The length of the common normal is measured using a micrometer or digimatic gear-tooth micrometer.				
2	Damaged thread	Thread gauges and visual inspection should check the condition of the threads. Parts with a thread stripping of more than two threads, dents, nicks and thread chipping, edge wear of more than 0.5 mm shall be discarded.				
1	2	3	4	5	6	7
3	Surface wear in roller bearing 7507	35±0.008	34.96	Micrometer or bracket	8111-03496D MK 50-2	± 0.004
4	Spline wear by thickness	$4^{-0.050}_{-0.174}$	3.6	Gear tooth micrometer	M325-2	±0.01
5	Through-cracking, teeth breakdown	are excluded		Inspection	–	–
Front axle shaft 52-2308063 (figure 2)						
1	Tooth wear by thickness	The length of the common normal is checked at three locations at approximately 120 °. The length of the common normal is measured using a micrometer or digimatic gear-tooth micrometer.				

2	Damaged thread	Thread gauges and visual inspection should check the condition of the threads. Parts with a thread stripping of more than two threads, dents, nicks and thread chipping, edge wear of more than 0.5 mm shall be discarded.				
3	Surface wear in roller bearing 7507	35±0.008	34.96	Micrometer or bracket	8111-03496D MK 50-2	± 0.004
4	Surface ware in gland seal	$30_{-0.130}$	29.65	Micrometer or bracket	8111-02965D MK 50-2	± 0.005
5	Spline wear by thickness	$4^{-0.050}_{-0.174}$	3.6	Gear tooth micrometer	M325-2	±0.01
6	Full radial run-out of the outer surface of the shaft relative to the common axis at a diameter of 30 mm	–	0.03	Run-out device	PBM-500	0.032
7	Through-cracking, teeth breakdown	are excluded		Inspection	–	–
Gear 52-2308061 (figure 3)						
1	Tooth wear by thickness	The length of the common normal is checked at three locations at approximately 120 °. The length of the common normal is measured using a micrometer or digimatic gear-tooth micrometer.				
2	Spline wear	Thread gauges and visual inspection should check the condition of the threads. Parts with a thread stripping of more than two threads, dents, nicks and thread chipping, edge wear of more than 0.5 mm shall be discarded.				
3	Surface wear in roller bearing 208	$40^{+0.020}_{+0.003}$	39.95	Micrometer or bracket	8111-03995D MK50-2	± 0.004
4	Surface wear in roller bearing 8208	$38_{-0.620}$	37.30	Micrometer or bracket	8111-03730D MK50-2	± 0.004
5	Surface wear in roller bearing 36209K1	$45^{+0.020}_{+0.003}$	44.98	Micrometer or bracket	8111-04498D MK50-2	± 0.004
6	Through-cracking, teeth breakdown	are excluded		Inspection	–	–

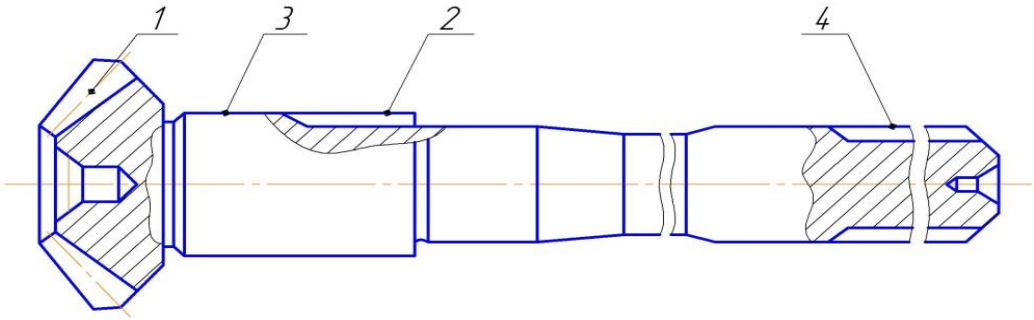

Figure 1. Front axle half shaft 52-2308065: 1, 2, 3, 4 - defect number in figure and in table 1.

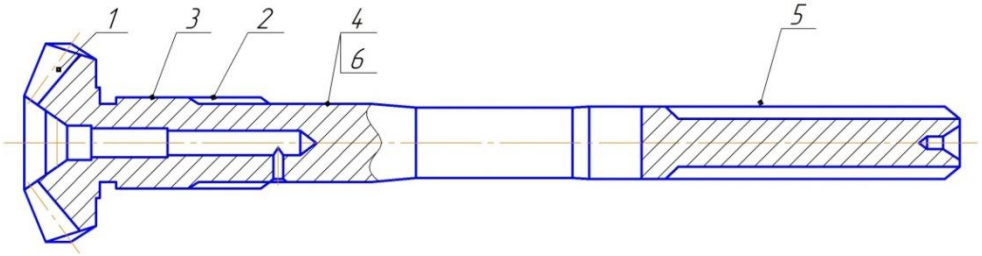

Figure 2. Front axle shaft 52-2308063: 1, 2, 3, 4, 5, 6 - defect number in figure and in table 1.

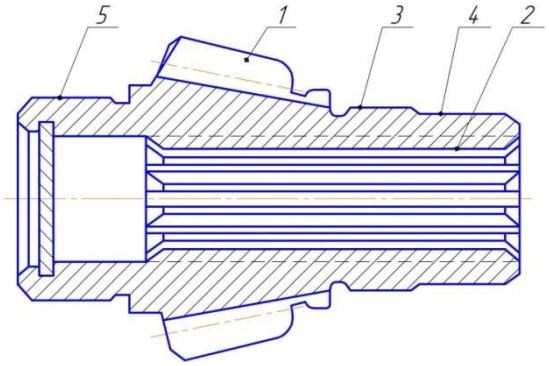

Figure 3. Gear 52-2308061: 1, 2, 3, 4, 5 - defect number in figure and in table 1.

The grade of their steel was determined from the physical and mechanical parameters of the investigated parts. As a rule, shafts, half-shafts and gears are made of the following steel grades: 40KH (GOST 4543-72) and 35KHGSA (GOST 4543-72).

Table 2 shows the chemical composition of 40KH steel corresponding to the standards. This grade contains 0.40% carbon *C* and less than 1.5% chromium *Cr*.

Table 2. Chemical composition of 40KH steel, %.

No.	Content	C	Si	Mn	Ni	S	P	Cr	Cu	Fe
1	Minimum	0.36	0.17	0.5	up to	up to	up to	0.8	up to	
2	Maximum	0.44	0.37	0.8	0.3	0.035	0.035	1.1	0.3	97
3	Average	0.4	0.54	0.65	0.15	0.015	0.015	0.95	0.15	

Table 3 shows the chemical composition of steel 35KHGSA corresponding to the standards. The decoding of the marking demonstrates the content of alloying additives in %.

Table 3. Chemical composition of 35KHGSA steel, %.

No.	Content	C	Si	Mn	Ni	S	P	Cr	Cu	Fe
1	Minimum	0.32	1.1	0.8	up to	up to	up to	1.1	up to	
2	Maximum	0.39	0.4	1.1	0.3	0.025	0.025	1.4	0.3	95
3	Average	0.355	0.75	1.9	0.15	0.0125	0.0125	1.25	0.15	

The contents of the chemical composition of steels, their minimum and maximum values are indicated in tables 2 and 3. These indicators are very important in the manufacture of each type of considered parts.

Table 4. Characteristics of materials used in the manufacture of transmission shafts.

No.	The name of detail	Catalog number	Steel grade	Density strength, kg/m^3	Tensile strength, MPa	Yield strength, MPa
1	Front axle shaft	52-2308063	40KH	7820	1570	1420
2	Front axle half shaft	52-2308065	35KHGSA	7875	1910	1640
3	Gear	52-2308061	ST3	7850	372	1350

Table 4 shows the characteristics of the materials of the investigated spare parts. For comparison, ST3 steel characteristics are given, which is often used, in order to reduce the cost of production, by unscrupulous producers to replace high-quality alloy steel. ST3 steel has significantly lower values of material strength and its use leads to malfunctions.

Thus, the control of the physical and mechanical properties of the material makes it possible to identify inconsistencies in hardness, chemical composition, material-corrosion resistance and other parameters, which can prevent failures during operation, both of the spare part itself, and in general of all agricultural equipment [11].

It is proposed to control the geometrical and physical-mechanical parameters of the spare parts under investigation using the developed "Automated measuring device" [12-13] and mechanical measuring instruments to compile a comparative analysis of the control results. The results obtained will be entered into special tabular forms in the form of a card of measurement results [14].

Comparative data on the results of quality control of spare parts for agricultural machinery between an automated measuring device and mechanical measuring instruments will be entered in a special tabular form, where the absolute and relative errors during measurement are calculated [14-16].

3. Conclusions

From all the above, it can be concluded that quality control of spare parts for agricultural machinery is currently an urgent task to ensure high-quality machine repair. It is due to the fact that a large share of low-quality counterfeit or counterfeit products is presented on the market.

The main reasons for failures are design defects in the manufacture of parts. As the spare parts under study, the details of the final drive gearbox of the MTZ-82.1 tractor are considered, namely, parts of the following types: front axle shaft 52-2308063; front axle half shaft 52-2308065; gear 52-2308061. The reasons for the failure of such parts are the inconsistencies between the physical, mechanical and geometric parameters. It is planned to control these parameters using mechanical measuring instruments and a developed non-contact automated measuring device to compare their readings, identify the performance and accuracy of control.

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