Testing the rigidity of the universal flanged centre shifter while sanding crankshaft necks of agricultural tractors

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Abstract. The repair and mechanical workshop, where the current repair of equipment is carried out, is an integral part of the technical service of an agricultural enterprise. There are specialized repair companies involved in restoration of basic machine parts. The development and implementation of advanced technologies for restoring parts will improve the quality of repairs and extend the service life of agricultural machinery. A universal flanged centre shifter is a device designed to shift a part relative to its axis of rotation before machining, for example, before sanding crankshaft necks. One of the factors affecting the accuracy of mechanical cutting and subject to research in this paper is the rigidity of the technological system "machine – tool – part". The rigidity of the technological system is understood as the ability to provide resistance to deformation forces.

1. Introduction

The crankshaft is the basic part of an internal combustion engine. The process of the agricultural tractors' crankshafts restoration is possible in the conditions of specialized repair enterprises [1–6]. These are included in the structure of the repair and maintenance base of the agro-industrial complex enterprises. During the days of planned economy, some of these companies specialized in repairing certain equipment brands. However, nowadays the conditions of market economy make a universal approach necessary for the technological preparation of repair production. In this regard, it is important to improve the functionality of technological equipment. The object of research in this work is a machine tool called a universal flanged centre shifter [7]. The subject of research is the technological process of sanding the necks of the crankshafts of agricultural tractors, which is carried out in order to restore the crankshafts by the method of repair dimensions.

2. Theoretical studies

A universal flanged centre shifter is a device to shift a part relative to its axis of rotation before machining, for example, before sanding crankshaft necks. In contrast to the standard centre shifter of a circular sanding machine 3A423 the universal flanged centre shifter (UFCS) has a lower mass, which reduces the moment of inertia when starting the machine and, accordingly, decreases the torsion deformations of the crankshaft. In addition, UFCS it makes shifting the workpiece when it is based in two dimensions possible. The combination of these advantages increases the accuracy of sanding the crankshaft necks.

UFCS, shown in the figure 1, consists of a body that is bolted to the crankshaft flange in the longitudinal holes of the corpus. The dimensions of the structural elements are appropriate to attach the
body to the crankshafts flanges of various constructions. A T-shaped groove is made around the circumference on the outer surface of the body. A rotary table is bolted to the corpus in a T-shaped groove. In the end part of the rotary table, two T-shaped slots are made. There two bridges with centre holes are bolted to the table, where the centre of the tailstock of the grinding machine presses the crankshaft. By turning the table around its axis and moving the bridges in a radial direction, the centre holes of the bridges are moved to the position required for pre-basing the crankshaft. When the bolted connections are tightened and the centre of the tailstock is pressed in the centre hole of the bridge, the crankshaft is secured before sanding the necks. The final basing in accordance with the required tolerances is carried out by adjusting bolts.

One of the factors affecting the accuracy of mechanical cutting is the rigidity of the "machine – tool – part" (MTP) process system. The rigidity of the technological system is understood as the ability to provide resistance to deformation forces [8].

\[
\gamma = \frac{P_y}{y},
\]

were \(\gamma\) is the rigidity of the technological system, N/\(\mu\)m, \(P_y\) is the radial component of the cutting force, N, \(y\) is an offset of the workpiece relative to the sanding wheel, measured by the normal line to the treated surface, \(\mu\)m.

While grinding cast iron

\[
P_y = 2P_z,
\]

were \(P_z\) is a tangent component of the cutting force during sanding [9].

\[
P_z = 1000C_0s_dyo^7D_{p}k_1k_2k_3/v_u,
\]
were $C_o$ is the coefficient that takes into account the method of sanding (for mortise sanding with radial feed $C_o = 0.0184$), $s_y$ is a radial feed, mm/min, $v_p$ is a circumferential speed of the part, m/min, $D_p$ – workpiece diameter, mm, $n$ is the degree indicator (for outdoor sanding $n = 0.2$), $k_1$ is the correction factor for the hardness of the circle (for hardness $C k_1 = 1.16$), $k_2$ is the correction factor for the width of the circle (for the width of the circle $B = 24$ mm $k_2 = 0.8$), $k_3$ is the correction factor for the workpiece (for steel $k_3 = 1$), $v_w$ is a circumferential speed of the sanding wheel, m/s.

The standard stiffness value for round sanding machines [4] is within $\gamma = 20...33$ N/µm. It is also possible to determine the stiffness of individual system elements MTP. For example, the stiffness of the process pair "tool – workpiece" can be expressed as follows:

$$\gamma_{tw} = \frac{P_y}{y_w},$$

were $\gamma_{tw}$ is the stiffness of the "tool – workpiece" process coupling, N/µm, $y_w$ is an offset of the workpiece relative to the bed machine tool, µm.

It should be noted that it is possible to create such processing conditions where the rigidity of the workpiece can be neglected. For example, by minimizing the bending moment from the action of a force on the workpiece $P_y$. Then the stiffness adaptations $\gamma_t = \gamma_{tw}$.

3. Experimental studies

In our case, it is interesting to compare the experimental stiffness values of the technological system MTP of a specialized round-sanding machine 3A423 using a standard cartridge centre shifter and a universal flanged centre shifter. In this regard, it became necessary to conduct tests, the main stages of which are the following:

1. Fixing the crankshaft to the left using a standard centre shifter, and to the right – using UFCS.
2. Creation of measuring bases by sanding the extreme connecting rod necks of the crankshaft in order to ensure that there is no radial runout of the surfaces at the contact points of measuring pin of the hour-type indicator.
3. Measuring the displacement of the left connecting rod neck of the crankshaft $y_1$ relative to the machine bed during mortise sanding (figure 2, a).
4. Measuring the displacement of the right crank neck of the crankshaft $y_2$ (figure 2, b).
5. Calculating the radial component of the force $P_y,$ according to the formulas 2 and 3.
6. The determination and comparison of stiffness values, respectively, of the standard cartridge - centre shifter and UFCS.

The tests were conducted under the following conditions:

- a D-240 engine crankshaft of agricultural tractors MTZ-80, MTZ-82;
- dial indicator with measurement 0.001 mm;
- sanding mode: $s_y = 12$ mm/min; $v_w = 28$ m/s, $v_p = 4$ m/min.

Calculated value of the radial component cutting forces (formulas 2 and 3) $P_y = 87$ N.

As a result of tests, experimental values of displacements of the extreme connecting rod necks of the crankshaft were obtained during mortise sanding under the action of radial component of the cutting force $P_y$: left neck $y_1 = 2$ µm; right neck $y_2 = 2.5$ µm.
Figure 2. Measuring the displacement of the crankshaft connecting rod necks during a stiffness test centre shifter cartridges: $a$, $b$ – measuring the offset of the left and the right crank necks respectively, 1 – standard cartridge – centre shifter; 2 – sanding wheel, 3 – crankshaft, 4 – universal flanged centre shifter, 5 – hour-type indicator

Thus, the rigidity of the standard centre shifter

$$\gamma_{SCS} = \frac{P_y}{y_1} = \frac{87}{2} = 43.5 \text{ N/}\mu\text{m},$$

(5)

rigidity of the universal flanged centre shifter

$$\gamma_{UFCS} = \frac{P_y}{y_2} = \frac{87}{2.5} = 34.8 \text{ N/}\mu\text{m}.$$  

(6)

The results of the UFCS hardness tests is 20% less than the stiffness of a standard centre shifter cartridge. Nevertheless, the value $\gamma_{UFCS} > 33 \text{ N/}\mu\text{m}$, that is a little more than the standard. In addition, the value of elastic deformation $y_2$ can reach 20…80% of the total processing error [10], which should not exceed the tolerance on the side of the connecting rod being ground $T_d/2 = 0.01 \text{ mm}$. In our case, the strain value $y_2$ is 25% of this value.

4. Conclusion

Thus, it can be claimed that the rigidity of the universal flanged centre shifter is quite sufficient to ensure the required accuracy of sanding the crankshaft necks, and the advantages UFCS described above makes using of centre shifter in repair production possible.

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