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A STUDY ON THE EFFECT OF THE BEARING CLEARANCE OF THE WHEELS ON THE MOVEMENT OF THE BAND SAW BLADE

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ABSTRACT

The present work refers to verification of the axial run-out of the band saws blades in band saw machines, as their geometric accuracy. It has been determined that the axial force is applied when rotating the wheels by hand, which, in the presence of bearing clearances, results in a displacement of the band saw blade in one direction for each complete rotation which does not allow its geometric accuracy to be determined.

The effect of the bearing clearances of the wheels on the trajectory described by the back part of the band saw blade is studied. The deflection of the crown of the guide wheels when applying a force of 150 N in the direction of feed for worn and new bearings was measured, as well as the displacement of the back of the band saw blade in this direction for these two bearings. Displacement of 0.2 – 1.1 mm of the band saw blades in one direction has been detected for each complete rotation which depends on the condition of the bearings. It is recommended that such verification should be carried out on relatively new bearings and that no axial force will be applied to worn ones.

Key words: band saw machines, band saw blades, run-out of band saw blade, frontal run-out.

INTRODUCTION

In band saw machines, as in many others, the geometric accuracy of some of the elements of the cutting mechanism is essential for their operation. One of the geometric inaccuracies of this mechanism is the frontal run-out of the crown wheel, which is regulated in standards for universal and re-saw band saw machines (BDS 5816-1989 and BDS 9678-1972). A second geometric inaccuracy in this mechanism is the deviation from the straightness of the band saw on its back side, which during operation is expressed in its run-out in the direction of feed. This geometric inaccuracy can be found on a special table, which most companies do not have (Obreshkov 1976, Obreshkov 1998). The specified geometrical inaccuracies – the frontal run-out of the crown of the band saw wheels, as well as the run-out of the band saw blade itself, as an accumulation of errors, can cause a total run-out of the band saw blade (Vlasev 2018). This run-out is not included in the known standards for geometric accuracy of band saw machines. In the previous standard for geometric accuracy of universal band saws machines, which is not up-to-date at present, as well as in the literature (Filipov et al. 1983), it is recommended to run-out the band saw blade on its back side 0.6 mm only for universal band saw machines.

The study of the run-out of band saws is important because it has been established theoretically (Vlasev 2018) that as a result of it, the cutting force can be increased up to 44% for different sections of them under a harmonic law of this run-out. It has also been found that with an inharmonious law of this run-out, this force can increase significantly. It has been found experimentally that the shape of the curvature of the band saws can cause sections of them to move to the cutting detail at a speed more than twice the theoretically calculated, which leads to a load of these sections with cutting forces of about 190% (Vlasev et al. 2019).

The run-out of the band saw blade is measured on its back side with a measuring clock, turning the band saw wheels by hand (Filipov et al. 1983). This verification, as mentioned above, applies to universal band saw machines, and it is not specified exactly how to drive them and where to grip them.

For band saw machines with wheels that have spokes or when they are thick but with slots, turning them is easy and convenient. This is because they can be attached to the spokes or the slots can be used for this purpose. When the wheels are solid, turning them by hand is difficult due to the tensioning of the band saw and the lack of a convenient grip. A possible place for gripping the wheel is the crown between the two branches of the band saw blade, where it does not come into contact with it. Turning them is difficult because the surfaces are very smooth, both the working area of the crown and its back side, which is painted. For these reasons, pure tangential force cannot be imparted to turn the wheels by hand, but additional axial force is introduced, which causes some inaccuracies. This was found in the study of the run-out of band saw blades, where in different modes of drive there is no recurrence at several consecutive rotations of the band saw blades (Vlasev et al. 2019). Therefore, the term "band saw blade movement" is used in the present work, as it refers not only to its run-out, but also to its displacement.

The aim of the present work is to establish the influence of the clearances in the bearings of the wheels on the displacement of the band saw blades in different ways of their drive when checking the axial run-out. In addition, to establish the correct way to drive the band saw blade for this check.

METHODOLOGY

According to the aim, the measurements consist of two parts. The first part is to measure the displacement of the crown of the wheels when applying force in the axial direction, in the direction of feed and opposite to it. The purpose here is to determine the clearance in the bearings. The second part is measuring the displacement of the band saw blade for three of its full rotations when gripping the crown of the upper band wheel from its front and rear part. The purpose of the second part of the measurements is to determine how the clearances affect these displacements. The measurements were made for two conditions of the band saw machines – when the bearings were changed within 3 months and during their operation for 15 – 18 months.

The application of the force is at the place where the band saw wheels rotate in the second group of measurements. The place designated for this purpose is the most convenient for turning the wheels. It is between the line connecting the axes of the two wheels and the contact of the ascending branch of the band saw blade with the wheel.

The first part of the measurements is performed with the band saw blade removed, and the force is applied in the direction of the feed and back to it with a dynamometer. The magnitude of the applied force is 150 N, determined by the radial cutting force for a cutting power of 17000 W, according to (Filipov 1977, Bershadsky and Tsvetkova 1975, Ivanovsky et al. 1972 Genchev 1978). The obtained deviations are measured with a measuring clock according to the literature (Filipov et al 1983, BDS 5816-1989).

The displacement of the band saw is measured on its back with a measuring clock for three full rotations between the two band saw wheels, in the place of the cutting material. The measurement was performed at the same place on the band saw blade, marked with a sign. The drive of the hand of a band saw blade is done by turning the upper band wheel, when gripping the crown on its front side for three of its turns. The same is repeated when gripping on its rear side, with the machine running briefly between the two measurements to carry out the next measurement under the same conditions. The part from which the materials are feeded is accepted as front. In this way the grip of the wheel, an axial force is applied on it in the direction of the feed. Such a force occurs due to the asymmetrical grip (the crown cannot be grasped on either side of it with one hand as it is very wide). The axial force is not maintained at a certain level because the rotation is by hand. It is measured approximately. The readings of the measuring clock were used. Its size during the experiments is 100 – 130 N.

It is planned to make experiments with symmetrical loading of the band wheels as well.

The machines used to perform the measurements are: 1. Resaw band saw *BD 111 M*; 2. Resaw band saw *ÜSTÜNKARLI UYM 100*; 3. Band saw with carriage feed *ÜSTÜNKARLI UHM 100* ; 4. Horizontal band saw MHB – 80, *Arsov 90 Ltd*. Figures 1 and 2 show the general views of two of the studied machines.

Figure 1: General view of a band saw machine *ÜSTÜNKARLI UHM 100* – Turkey

Figure 2: General view of a band saw machine *Arsov 90 LTD* – Bulgaria

Figure 3 shows the method of measuring the displacement of the band saw blade in one of the tested machines.

Figure 3: Determining the displacement of a band saw blade with a measuring clock

RESULTS AND ANALYSIS

The results of the conducted experiments, according to the set aim and methodology of work, are shown in Table 1 for two groups of measurements – deviations of the band saw wheels when applying force in the direction of feed and displacement of the band saws when turning them. The results for each of these groups are for the operation of the bearings – up to 3 months and over 15 months. Measurements with more than three band saw blades have been made for each machine, but since the results are identical, only one of them is shown.

Regarding the deviation of the band saw wheels due to the clearances in the bearings, for those that have been in operation for less than three months, the deviations are significantly smaller than those over 15 months. They are 3-4 times smaller than those who worked for more than 15 months. The deviations in the direction of the feed and the opposite ones are approximately the same and no specific dependence is observed. These are results that are expected and for the conducted researches it is not necessary to analyze them, as they are used as a factor for displacement of the band saw during its rotation.

Table 1: Checks for the deflection of the band saw wheels and the displacement of the band saw blades in the direction of the feed when turning them by hand

Machine №	Operation [months]	Type of check							
		Bearing clearance, /deviation/ [mm]		Displacement of the band saw blade when gripping by front and back of the crown [mm]					
		Direction, (+)	Direction, (–)	Front grip /Rotation №/			Rear grip /Rotation №/		
				1	2	3	1	2	3
1	0.5	0.08	0.06	–0.05	–0.09	–0.13	0	+0.05	+0.11
2	1	0.13	0.17	–0.08	–0.11	–0.19	+0.09	+0.15	+0.14
3	3	0.21	0.18	–0.1	–0.12	–0.23	+0.08	+0.1	+0.17
4	2	0.12	0.14	–0.04	–0.07	–0.12	+0.03	0	+0.09
1	18	0.38	0.31	–0.18	–0.62	–0.81	+0.13	+0.38	+0.64
2	13	0.26	0.28	–0.26	–0.54	–0.98	+0.29	+0.33	+0.88
3	17	0.41	0.33	–0.32	–0.71	–1.1	+0.41	+0.55	+0.91
4	14	0.46	0.38	–0.11	–0.11	–0.15	+0.02	0.09	+0.12

When moving the band saw blades, specific patterns are observed. It should be noted here that the displacement is reported cumulatively, i.e. for every next rotation the total displacement is taken into account.

The first regularity that is observed for all machines is that with each rotation of the band saw blade its displacement increases, regardless of the direction of displacement. This is very clearly seen in bearings with a longer operation life. The explanation of this phenomenon is that each time the wheel is turned, it is given force in the direction of the feed.

The second regularity, that is observed, is that the displacement of band saws in bearings with a longer service life is significantly greater than the displacement in those with a shorter service life. The difference is greatest in the third machine, being approximately 6 times and reaching 1,1 mm. This gives reason to recommend: not to check the geometric accuracy of band saw blades in bearings with a long service life. Or if they are made – to take into account this factor.

The third regularity is the direction of displacement of the band saw blades when gripping the crown of the wheels from different sides. When gripping on the front side, the band saw blades move against the feed direction, and when gripping on the rear side, they move in the feed direction. There are no significant differences for the two directions. An explanation for this phenomenon is that the wheel changes its axis of rotation due to the clearance in the bearings and the applied force in the feed direction and guides the band saw blade in the direction of the displaced crown of the wheel.

Studies on symmetrical loading of the wheels when gripping their crown on both sides have also been done. Displacement of the band saw blade in one direction is not observed and there is a relative repeatability for each next rotation (Vlasev et al. 2019). In this case, a check for running-out the band saw blade can be made. Such a rotation is very difficult, as there is no suitable place for the person doing the inspection to stand. The main difficulty for symmetrical gripping of the wheels is their cover, and it is not justified to disassemble elements of the machine for one inspection. One solution for conducting such an inspection is to turn the band saw blade by gripping and pulling it in the straight section.

From the conducted experiments another regularity is observed in the last machine, in which the deflection of the wheel is comparable to the deflections of the wheels of the other machines, but the displacement of the band saw blade is the smallest and reaches 0.15 mm on the third rotation in the opposite direction and 0.06 mm in the feed direction. As can be seen, the displacement of the band saw blade is insignificant in the feed direction. The small displacement of the band saw blade, as well as the large difference in the place of attachment of the crown, can be explained by the suspension of the wheels of this machine. They are cantilevered, while in other machines they are located between the two bearings. When gripping the crown on the front or back side, a torque is created on the axis of the wheel. In this machine, a torque is created on the axis of the wheel from the tensioning of the band saw blade, while in other machines such a torque is not created. When gripping the crown on its front side, the moment created by the rotational force is unidirectional with the moment of tensioning the band saw. When gripping the crown on its rear side, the torque created by the rotational force is opposite to the torque of tensioning the band saw blade. For this reason, the displacement of the band saw is different for the two turning points. The most important thing for the small displacement of the band saw is that the tensile force of the band saw wheel is much greater than the force for its rotation, due to which the change of the axis of rotation is very small. Figure 4 graphically presents the result of the arithmetic mean values of the displacement of the three rotations for each of the tested machines – when gripping front and back of the crown, at the beginning of the operation of the bearings and after a certain period of working time.

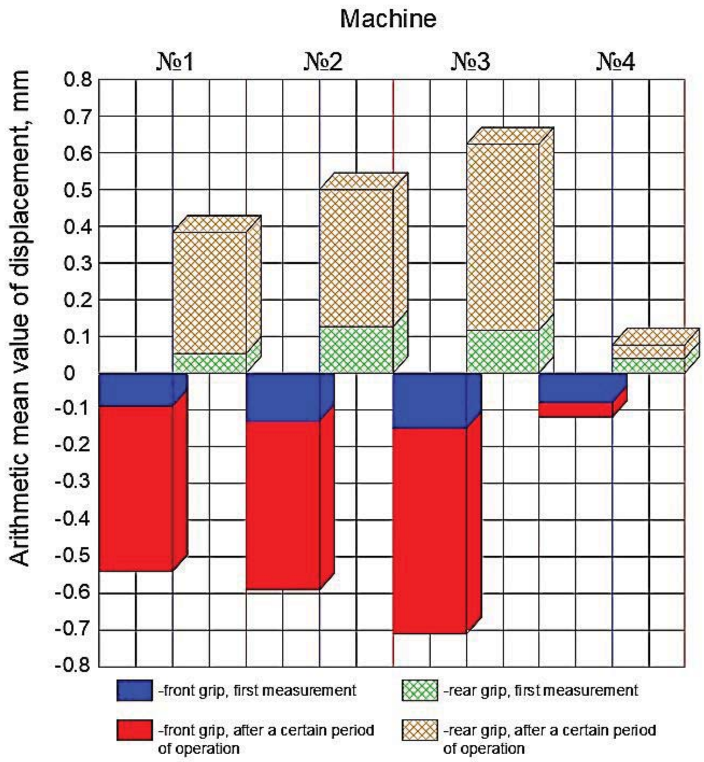

Figure 4: Arithmetic mean values of the displacement of the three rotations for each of the tested machines

CONCLUSION

The following conclusions can be drawn from the conducted experiments:

1. The rotation of the band saw wheels with the application of force in the direction of feed, when checking the beating of the band saw blade, leads to its displacement in this direction. This displacement is significant, especially during longer operation of the bearings and does not allow proper reading of the axial run-out of the band saw blade.

2. When turning the wheels, no force must be applied to them in the direction of the feed. They must be attached to the spokes or to the holes, if any. If the band saw wheels are smooth and difficult to turn, it is possible to turn them by pulling the band saw blades.

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