

A STUDY OF THE RUN-OUT OF BAND SAW BLADES IN BAND SAW MACHINES

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ABSTRACT

It has been studied the run-out in the cutting mechanism of band saw machines. The run-out of the band saw blade is viewed as the sum of the frontal run-out of the guide wheels and the band saw blade's own run-out. Measurements have been made on the frontal run-out of the guide wheels and on three successive full rotations of the band saw blade. It has been found that there is no repeatability of the deviations in any subsequent or preceding rotation. The main result of the study is that the frontal run-out of the guide wheels is very small compared to the actual run-out of the band saw blade, but it is the factor influencing the shape of the deviations in its rotation. It is between 0.12–0.39 mm. The total run-out of the band saw blade, in 60% of all measurements, is in the range of 0.8–1.5 mm. Various band saw blade deviations have also been identified, according to which the cutting force variation can be determined for different parts of the blade.

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

INTRODUCTION

The cutting forces, for band saw as well as other woodworking machines are the basis for the strength dimensioning of the elements of their cutting mechanisms as well as other machine elements. These forces need to be known for the proper operation of the machines.

In these machines, as well as in many others, the geometric accuracy of some of the cutting mechanism's elements is essential to their operation. One of the geometrical inaccuracies of this mechanism is the frontal run-out of the crown of the guide wheels, which is regulated by standards for universal band saws (BDS 5816-1989) and band resaws (BDS 9678-1972). A second geometric inaccuracy in this mechanism is the linearity deviation of the band saw blade, which during operation is expressed with its own axial run-out. This run-out, in the known standards of geometrical accuracy of the band saw machines, is not included for verification. The

only literary source (Filipov et al.1983), found by the authors, suggest a run-out on the front side 0.6 mm only in universal band saws. The testing of the run-out of the band saw blade is of importance, as it has been established (Vlasev 2018) that because of it the cutting force can increase up to 44% in different regions.

The above-mentioned geometrical inaccuracies – the frontal run-out of the crown of the guide wheels, as well as the run-out of the band saw, can cause the run-out of the band saw blade. Here it is necessary to introduce some clarifications regarding the terms used in the present work, as well as to specify that the run-out is axial. It has been assumed that the frontal run-out of the crown of the guide wheels shift the band saw blade along with its linearity deviations, which are perceived as "its own run-out of the band saw blade". The latter, combined with the mistakes of the frontal run-out of the crown of the guide wheels, is perceived as a "total run-out of the band saw blade".

The first geometrical inaccuracy – the frontal run-out of the crown of the guide wheels can cause aperiodic shift back and forth of a part of the band saw blade to the processed material. This would be the case for each guide wheel, each of which would shift part of the band sawblade independently of the other. For the second geometric inaccuracy, the reasons why it is obtained can be indicated. They are various – the non-linearity of the back of the band saw blade, inaccuracy of attachment of both ends (soldering or welding), rolling, as well as cracking of the blade. The inaccuracies caused because of the first three reasons can be determined during a control check before placing the band saw blade on the machine, the latter, on the other hand, may appear during operation of the machine and thus not be detected. There are recommendations, regarding the non-linearity of the back of the band saw blade, (Obreshkov 1998), (Obreshkov 1976), however, for the three following reasons mentioned above no such recommendations exist or at least are not known to the author.

THEORETICAL FORMULATION

As mentioned above, the geometrical inaccuracies can cause the run-out of the band saw blade, as a result of which a part of the band saw blade's teeth are periodically moving away and towards the processed material. Thus the speed of the approach is summed with the feed rate and the offset speed is subtracted from it. The latter means that the feed rate by which the cutting force is to be calculated, needs to be increased or decreased in accordance with the rate of the periodic approach or offset of the tooth line of the band saw blade to the processed material.

From the theoretical studies of the speed of the periodic approach or offset of the tooth line of the band saw blade to the processed material by a harmonic law (Vlasev 2018), it

has been determined that certain areas of it are periodically moving away and towards the processed material at a speed of up to 44% of the feed rate within a complete rotation. The latter means that the band saw blade is loaded in an asymmetric loop with the above shown increase compared to the traditional calculation method (Filippov 1977). As mentioned above, the theoretical studies are for the approach of sections of the band saw blade to the processed material under a harmonious law. It has been found that the greatest speed of this approach is caused by its own run-out, which is expressed by the formula (Vlasev 2018).

$$v_{max} = \pi \Delta f, \text{ m.s}^{-1}, \quad (1)$$

where:

v_{max} – the maximum velocity of offset of a section of the band saw blade caused by its own run-out, m.s^{-1} ;

Δ – maximum geometrical inaccuracy of the band saw blade, m ;

f – the oscillation frequency of the harmonic line, s^{-1} .

The maximum speed of this approach according to the above formula is in a harmonic law of its curvature in an unfolded form. From the formula, it can be seen that this speed depends on the frequency of oscillation of the harmonic line. This frequency is constant for the band saw blade. For a curvature having the shape of a sinusoid, in which the two half periods differ, this speed will be different for them. If the line is not harmonic and one half-period is smaller than the other, the frequency for that half-period can be assumed to be greater. This can be explained by the graphic representation of the curvature of the band saw blade in Fig. 1. Position 1 indicates the processed material and the direction feed U . Position 3 indicates the harmonic curvature line for which the theoretical calculations of the speed of movement of a section

according to (Filipov et al. 1983), with a measuring clock on its back part within a complete rotation. In this case, it is assumed that the run-out during movement of the tooth line is the same as that of the back part, since the latter is used as base during sharpening.

Since the band saw blade is a closed outline, one of the ways in which its curvature can be displayed graphically is in an unfolded form. To achieve this, the length of the band saw blade is divided into eight equal marked parts. The run-out is measured at the marked point, starting from the point of attachment of both ends. The band saw blade is set in motion by turning the guide wheels by hand according to (Filipov et al. 1983). Measurements are made on three consecutive full rotations of the band saw blades.

According to the theoretical formulation above, and as it can be seen from Figure 1, projection A1B1 of area AB of curve 2 is larger than projection CD1 of section CD of curve 3. The increase in the speed of approach of section CD of the band saw blade to the processed material can be determined by the ratio of segments A1B1 and C1D1. Approximately the same is the ratio of half-periods T and T1. With enough accuracy for practice, in this work this increase will be determined by the ratio of the two half-periods.

The machines used for the research are: 1. Band resaw BD 111 M and ÜSTÜNKARLI UYM 100; 2. Vertical sawmill band saw ÜSTÜNKARLI UHM 100; 3. Horizontal band saw MXB – 80; 4. Universal band saw UPS – 650.

RESULTS AND ANALYSIS

According to the method of operation, it is necessary to determine to what extent the frontal run-out of the guide wheels has an impact on the total run-out of the band saw blade. For this purpose, the machines on which measurements have been made are shown in Table 1, and in Figures 2 to 6 the total run-out of the band saw blades for the same machines is presented. For these figures, it is necessary to specify that points 0 and L correspond to both ends of the band saw which are joined together, and that point L corresponds to one period of its rotation. The three complete rotations are presented on a graph in order to determine the impact of the frontal run-out of the guide wheels on the total run-out of the band saw blade. These figures represent the most typical cases out of a total of 35 measurements on band saw blades.

Table 1: Results of the measurement of the run-out of the crown of the guide wheels.

Measurement	Frontalrun-out of the crown of the guide wheels[mm]				
	BD 111 M	UYM 100	UHM 100	MHB – 80	UB -650
Leadingguide-wheel	0,24	0,12	0,12	0,35	0,39
Operatedguide-wheel	0,28	0,06	0,2	0,4	0,27

The machine with the smallest measured total run-out of the band saw blade – 0.28 mm (Fig. 2) is vertical sawmill band saw UHM 100. The frontal run-out of the guide wheels is 0.12 and 0.2 mm, indicating that their run-out from may be equal to their sum –

0.32 mm. From the figure it can be seen that the frontal run-out of the guide wheels is commensurate with the total run-out of the band saw blade. From this it can be concluded that the ends of the band saw blade are connected very precisely and that the run-out

of the band saw blade is mainly due to the frontal run-out of the guide wheels. Another characteristic phenomenon is that at three rotations of the band saw blade, the shape of the

described curvatures is very different from Figures 3 to 6, which confirms the above thesis.

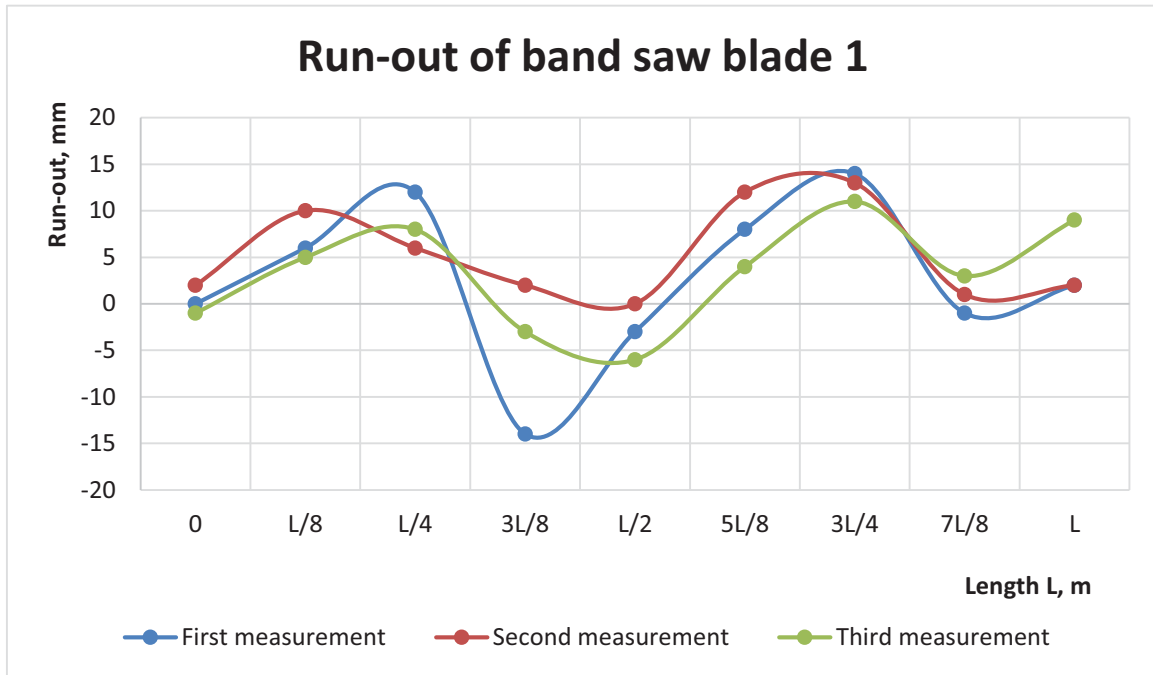


Figure 2: A graph of the total run-out of a band saw blade in a vertical sawmill band saw UHM 100 with a frontal run-out of the guide wheels 0.12 and 0.2 mm.

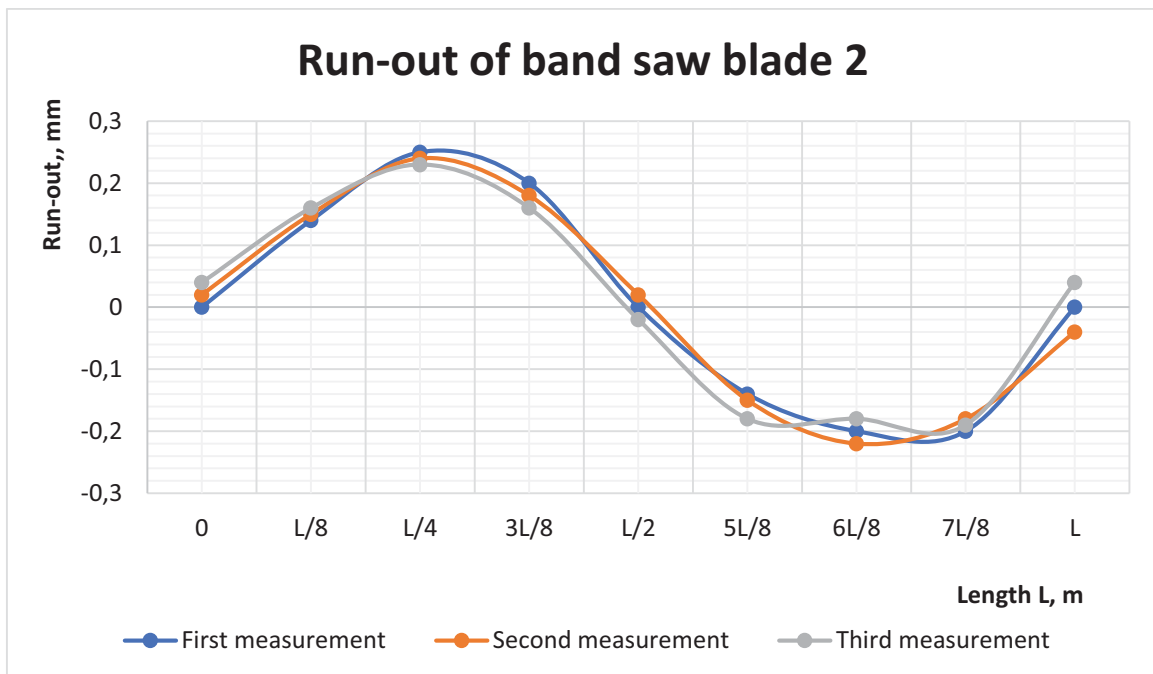


Figure 3: A graph of the total run-out of a band saw blade in a vertical sawmill band saw UYM 100 with a frontal run-out of the guide wheels 0.12 and 0.06 mm.

A second characteristic case is the UYM 100 vertical sawmill band saw, in which the

frontal run-out of the guide wheels is at least 0.06 and 0.12 mm and the total run-out is

0.47 mm. Here it is observed that in all three measurements the curvatures are very close to one another. This means that the frontal run-out of the guide wheels has a very low impact on the total run-out, and the run-out of the band saw blade has the most impact. Here, it should be noted that from all made measurements in only three of them the total run-out of the band saw blades is less than 0.6 mm for which theoretical calculations are made. In the two examined cases, the frontal run-out of the guide wheels and the total run-out of the band saw blade have very small values. In the following cases, both have greater values, the latter reaching values greater than 1.5 mm, which is 2.5 times greater than those in the theoretical calculations (Vlasev 2018).

In Figure 4, the frontal run-out of the guide wheels is 0.24 and 0.28 mm, and the total run-out of the band saw blade is 1.69 mm. Here it is seen that the total run-out is approximately three times greater than the previous one. Characteristic of the shape of the curvatures during the three rotations of

the band saw blade is that they do not differ significantly from each other as in Figure 2. This is explained by the considerably greater run-out of the band saw blade, where the frontal run-out of the guide wheels has little effect on the total run-out. From this graph, apart from the influence of the various factors regarding the shape of the curvatures, one can see their asymmetrical shape in terms of the size of the two half-periods. It is observed that most of the curvature along the band saw blade is located above the abscissa axis. Below it is the curvatures of the band saw blade's sections $0 - L/6$ (approximately) and $7L/8 - L$, which means that about 30% of the shape of the curvature is below the abscissa axis and 70% is above it. This asymmetrical position can be explained by the accuracy of attachment of both ends of the band saw blade. Since points 0 and L correspond to the point of attachment, this only means that they are not connected in parallel, but at an angle. This is particularly pronounced in band saw blade 4 (Fig. 5).

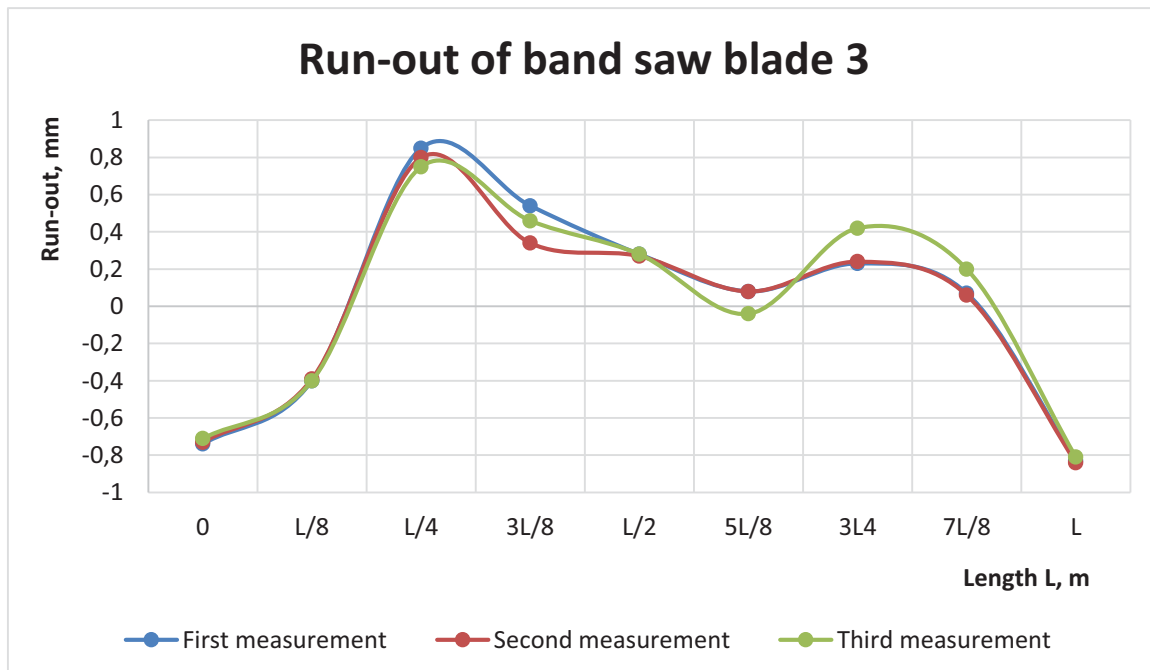


Figure 4: A graph of the total run-out of a band saw blade in band resawBD111M, with a frontal run-out of the guide wheels 0.24 and 0.28 mm.

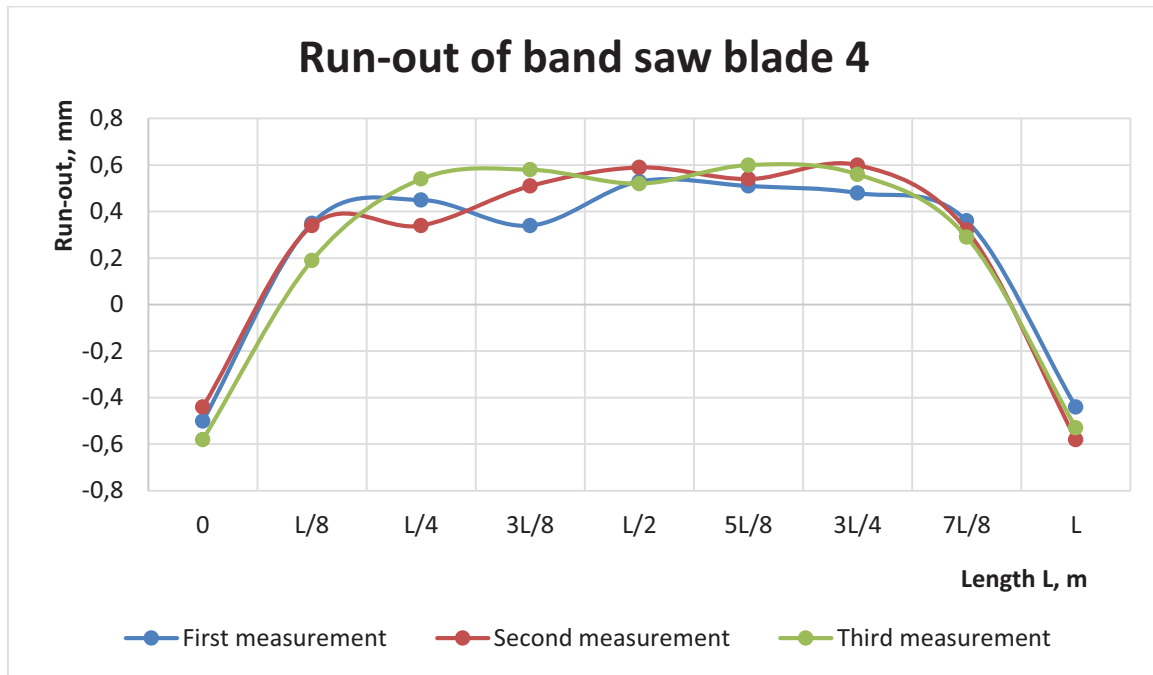


Figure 5: A graph of the total run-out of a band saw blade in band resaw MHB– 80 /1.14 mm/, with a frontal run-out of the guide wheels 0.35 and 0.4mm.

In this case, it can be seen that the larger part of the band saw blade has a small total run-out, about 0,2 mm, in the range of $L / 8$ to $7L / 8$. The larger part of this run-out occurs at the point of attachment of the band saw blade – from 0 to $L / 8$ and from $7L / 8$ to L . This curvature can only happen due to the inaccuracy of attachment of both ends of the band saw blade. In this area, as in the previous figure, can be seen a very small influence of the frontal run-out of the guide

wheels, which can be explained by the dominant influence of the band saw blade's own run-out.

In the experiments carried out, a shape of the curvature of the total run-out, mirroring those in Figures 4 and 5 can be observed (Fig. 6). This is explained by the way the two ends are joined. In one case, the curvature is convex, and in the other – concave. To achieve the main purpose of the present work, of significance is not the shape of the curvature but the length of the shorter half-period of the curvature (Fig. 1).

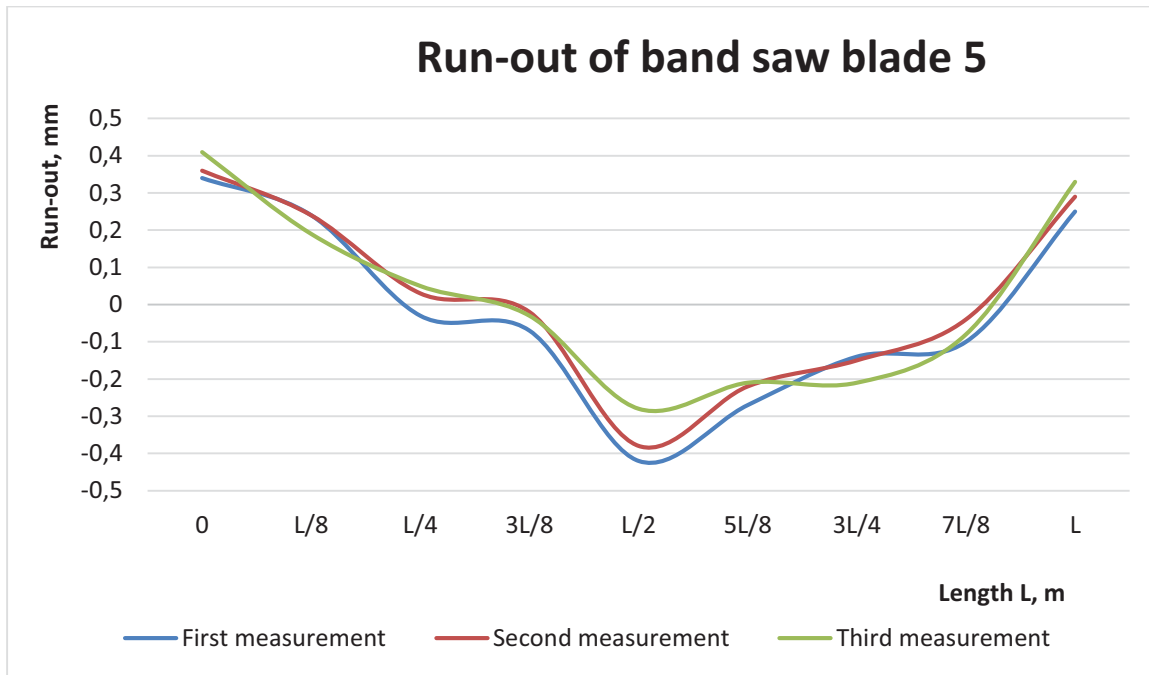


Figure 6: A graph of the total run-out of a band saw blade in a vertical sawmill band saw UHM 100 /0.83 mm/, with a frontal run-out of the guide wheels 0.2 and 0.12 mm.

As it can be seen from Figure 5, the sections from 0 to $L/8$ and from $7L/8$ to L form a curve close to a half-period of a sinusoid. Its size is approximately $L/4$ / corresponds to $T/4$ in Fig. 1 /, two times less than half-period $T/2$. According to the theoretical formulation above, the speed of approach of a section of the band saw blade with such a half-period to the processed material is twice as great. From the conducted experiments, it has been found that in 7 of them, which is 20% of all made measurements, they have half-periods of the curvature shape two times smaller than the theoretically calculated. This shows that in practice such cases are possible and should be taken into account in force and strength calculations.

The other cases are different combinations of the previous ones, but the predominant ones are those with an improper attachment at both ends. They have a total run-out of 0.8 to 1.5 mm and make up about 60% of all measurements.

CONCLUSIONS

From the made measurements on the run-out of the band saw blades, the following more important conclusions were made:

1. The total run-out of the band saw blades have maximum values of 1.6 – 1.8 mm in 20% of the band saw blades and values of less than 0.6 mm in only about 12% of them.
2. The frontal run-out of the guide wheels has a very small impact on the total run-out of the band saw blades due to their own great run-out, which in 68% of the cases is caused due to an improper attachment at both ends.
3. The shape of the curvature of the band saw blade in 20% of the cases is such that it causes movement of sections of the band saw blade to the processed material at a rate more than twice as great as the theoretically calculated one, which results in loading of these sections with cutting forces of about 190%.

4. It is necessary to pay close attention to the accuracy of brazing or welding machines as well as the qualifications of the workers servicing them.
5. According to the made measurements, it can be expected that in the sections of the band saw blade, which are closer to the processed material, the dulling of the incisors there may be more intense.

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