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RESEARCH ON THE SIDE DEFLECTION OF THE SAW BAND OF A JOINERY BAND SAW INFLUENCED BY THE SELECTED TECHNICAL AND TECHNOLOGICAL FACTORS

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Abstract:
The paper focuses on measuring and evaluating the impact of selected technical and technological factors - the height of adjustable guides and stretching force - on the side deflection of the saw band of a joinery band saw. There is a detailed description of the ways the side deflection can be measured. In order to find out the intensity of the stretching force was used portable tension meter SANDVIK 5000, enabling to check the tensile stress in the saw blades of a gang saw or in the saw bands of a band saw. The actual experiment was conducted on a joinery band saw, at the cutting rate vc = 15 m·s-1. The results of the measurements confirmed the theoretical assumption of the impact of the selected technical and technological factors on the stability of the saw band, where the side deflection decreases with increasing stretching force and increases with increasing height of the guides. The stability of the saw band affects the quality of the surface to be treated, thus saving the cost of machining the workpiece and making work productivity more efficient.

Key words: *band saw, saw band, stability, side deflection*

INTRODUCTION

Wood is an integral part of our lives. Since time immemorial, it has had wide use and long tradition. It is becoming more and more unavailable and currently ranks among the strategic raw materials. Trends in the processing of this renewable raw material are going through a qualitative evaluation, leading to rising requirements for the quality of processing facilities. The most widespread type of machining is saws. They are used to cut workpieces into smaller parts and to the desired shape. Saws are machines with a toothed tool that cuts wood into smaller pieces. In addition to other types of saws, band saws are indispensable for cutting logs as well as for secondary production processes. Band saw itself has no effect on wood. It is the cutting tool - saw band - that removes woodchips, and thus changes its size and shape. One of the main factors influencing the surface treatment is the band saw, therefore it is necessary to be rigid and stable [22].

Factors affecting the stability of a saw band

Stability of a saw band is the ability to withstand the force effects that tend to deflect a band away from the section plane and thus cause an uneven cut [4, 17].
The eigenfrequencies of the flexural–torsional vibrations of band saw blades and the limits of the instability regions are determined as a function of the tool parameters and the operating conditions [10]. Complete review about these subjects was published by Ulsoy, Mote and Szymani in 1978 [19], Wong in 1996 [20], Yang and Mote in 1990 [21], and others authors.
Stability of saw bands is influenced by a large number of factors, such as:

- Stress in saw bands,
- Straining of a saw band,
- Dimensions of a saw band,
- Inner stress of a saw band caused by rolling,
- Guide of a saw band,
- Capacity of a gullet,
- Transverse stability.

To achieve the required rigidity and the right movement, the band must be stretched properly, i.e. there must be sufficient tension in the cross-section [3]. By the evaluating saw blades are important three operation states: at rest (the engine is off), running idle (without sawing anything) and sawing. Saw band or its parts are strained by various stresses shown in Fig. 1.
The stability of a saw band and vibration with side deflection can be measured by vibration sensors.
Classification of vibration sensors [7, 18]

- According to measured variable: deflection sensors, speed sensors and acceleration sensors (accelerometers).
- According to shape: absolute and relative.
- According to principle: electrical, mechanical and optical.
- According to contact with the measured object: contact and non-contact.

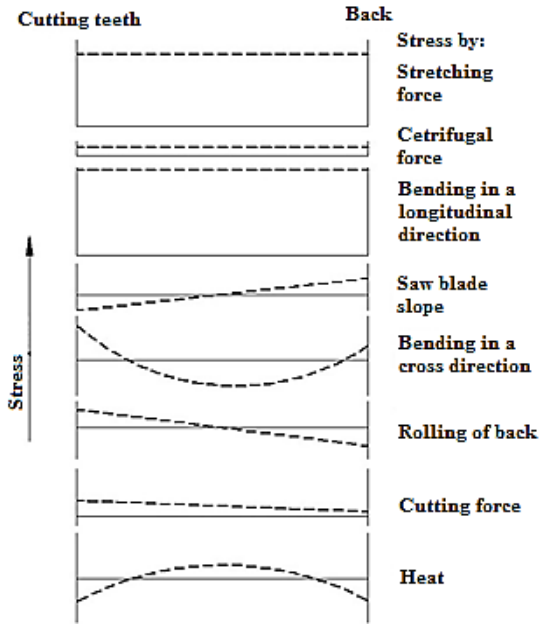


Fig. 1 Stresses in a saw band
Source: [7, 8].

Siklienka and Černecký (1997) applied holographic interferometry in the analysis of the distribution of stresses and deformation in saw bands caused by external influences. This method enables to explore the displacement of deformation on the surface of real objects. Within this non-contact method, the course of deformation is the property of an object only, its fit, and loading. They managed to get the interference pattern of the surface of an object covered with interference fringes whose density and shape correspond to the deformation of its surface. In order to evaluate the deformation, the records of two holograms are required – before and after deformation. This is so-called double-exposure method. Using a flash of laser light that illuminates a double-exposure hologram, we get the image of the recorded saw band which is subjected to the influences causing deformation. This method was tested in an experiment where loading force had an effect on a tooth of a saw band. The largest displacement occurred in tooth gaps, which greatly depends on the geometry of a tool [16, 9]. Barcík et al. (1998) measured the vibration of a saw band depending on the selected technical and technological factors which have an impact on the side deflection of the saw band of a log band saw, influencing the quality of timber and the temperature of a saw band that may also be affected (esp. in the tooth zone) by different cutting height. An optoelectronic method was used where a linear CCD camera is equipped with a semiconductor sensor. The camera detects the light intensity of a light source located behind the back of a saw band. In the given experiment conditions, the effects on the side deflection of the saw band of a log band saw (LBS), individually and in mutual interaction, the appeared in the following order: tensile stress, cutting rate, feed speed, free length of a saw band and cutting height. The influence of the tensile stress, cutting rate, feed speed and free length of the band on the temperature of the band was not so significant in the conditions of the experimental measurements [6].

Barcík and Naščák (1999) measured the vibration and its consequence – side deflection (SD) of the saw band of a joinery band saw in relation to the selected technical and technological factors using a non-contact method. The principle of measurement is the change of deflection of an infrared beam caused by shifting a saw band. A saw band is illuminated by a source of infrared radiation at an angle. The vibration and deflection of a saw band causes the deflection of a reflected infrared beam which is directed at the plane of a scanning photodiode. The output signal is to some extent proportional to the change in position of a band, which causes the deflection of the reflected infrared beam between the two areas of a double photodiode. The impact of all the studied factors on the side deflection of a saw band has been confirmed. With an increasing cutting rate, radius of curvature and width of a band, the side deflection was decreasing. With an increasing cutting height, the side deflection was increasing [5].
Siklienka (2004) measured the natural frequency of the vibration of the saw band of a LBS at the static load. He used an apparatus working on the principle of excitation of a saw band by electromagnetic vibration exciter and subsequent use of vibration sensor. During the excitation, natural frequency of a saw band is measured by tuning a tone generator until a resonance image is created. In case resonance appears, the excitation frequency equals to the natural frequency of a band. The measurements were carried out for various positions of guides. Statistical evaluation of the measurements regarding the impact of the delivery operating guide on the rigidity of a saw band has shown which guide position is optimal for a particular machine [15].

MATERIALS AND METHODS

The paper focuses on measuring and evaluating the impact of selected technical and technological factors – the height of adjustable guides and stretching force – on the side deflection of the saw band of a joinery band saw resulting in the loss of rigidity.
The measurements were carried out on the universal joinery band saw made by Croatian producer Prvomajska (production year 1983), type SELECT SU. The saw band used in the measurements was made by PILANA Wood s.r.o. Parameters of saw band PILANA 40 – C 75 are specified in Table 1.

Table 1
Parameters of saw band PILANA 40 - C 75

Band material		Carbon steel C 75
Material hardness (HRC)		38-44
Dimensions	**B**	25
saw band	**s**	0.5
[mm]	**h_z**	8
Length of saw band (mm)		3300
Saw teeth arrangement		Spring-set, sharpened
Tooth	**γ**	10
geometry [deg]	**β**	50
Max. tensile stress (MPa)		30

Measuring devices

Oscilloscope: PicoScope 2205, Inductive sensor: BALLUFF BAW M08EI-UAD15B-BP03

The principle of inductive sensor is based on the interaction between metallic conductors and an alternating electromagnetic field. In the scanned metal damping material, eddy currents are induced that draw energy from the field and reduce the size of oscillation amplitude. This change is evaluated by an inductive sensor (Table 2) [1].

Table 2

Parameters of the inductive sensor

Output signal	0 ÷ 10 V
Nominal supply voltage	24 V DC
Working voltage	15 ÷ 30 V DC
Nominal scan distance	1 mm
Operating ambient temperature	-10°C÷+70°C
Sampling frequency	1000 Hz
Maximum speed of measurement	≤20 m·s^{-1}

Tension meter SANDVIK 5000

Portable tension meter SANDVIK 5000 was used to check the tensile stress in the saw blades of a gang saw or in the saw bands of a band saw designed for wood or metal. This electronic device with a digital indicator of tension is low weight and allows easy installation on the measured point. Measuring length is 206 mm and the size of the groove in the fork is 15 mm [13].

Voltage source: Metex universal system ms-9150; PC with programme PLW Recorder; Magnetic holder 3 - D Atorn 3108 750 N; Feeler gauge tape Kinex 0.05 to 1.00 mm; Tape measure 2 m.

METHODOLOGY

The apparatus used for measuring the side deflection of the saw band (Fig. 2) consists of two main parts:

- Mechanical (magnetic holder of the inductive sensor),
- Electronic (PC, oscilloscope, terminal board, voltage supply, inductive sensor).

To measure the side deflection of the saw band, we used the measuring apparatus together with the object of measurement (the cutting tool – saw band) assembled in accordance with the scheme shown in Fig. 2, using an inductive distance sensor.

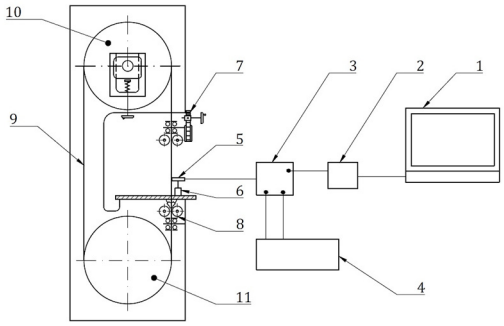


Fig. 2 Scheme of the measuring system
1 - PC with evaluation software, 2 - oscilloscope PicoScope 2205, 3 - terminal board, 4 - voltage supply Metex universal system ms-9150, 5 - inductive sensor, 6 - magnetic holder 3 - D Atorn 3108, 7 - upper adjustable guides, 8 - lower guides, 9 - saw band, 10 - driven disc, 11 - driving disc

Stretching force was adjusted by means of the motion screw within the tensing mechanism of the joinery band saw. The maximum intensity of the stretching force was calculated from the maximum permissible tensile stress set by the manufacturer of the saw band.

We chose two more values of tensile stress which had to be lower than the maximum permissible stress set by the manufacturer of the saw band, namely: σ_{t1} = 20 MPa and σ_{t2} = 25 MPa. The intensity of stress in the saw band was set by tension meter SANDVIK 5000 shown in Fig. 3.



Fig. 3 Setting the tensile stress in the saw band

The measurement was carried out at three different stretching forces F_{n1} = 430 N, F_{n2} = 515 N, F_{n3} = 600 N and at three different heights of guides which were chosen based on the parameters of the machine l = 100 mm, l = 150 mm, l = 200 mm.

RESULTS

Experimental measurement of the side deflection of the saw band of a joinery band saw was carried out at varying stretching force of the band as well as varying height of guides. The results include values for three different stretching forces and for three different heights of guides. The output file was in txt. format and was exported to Excel, where the tension values were converted to the values of side deflection (Fig. 4).

All measurements were evaluated from the number of values recorded by the sensor during one revolution of the band, after the conversion according to the Eq. (1), 330 values of side deflection were evaluated.

$$n_{vz} = \frac{L}{v_c} \cdot f_{vz} = \frac{3{,}3}{15} \cdot 1500 = 330 \qquad (1)$$

where:

L – band length (m),

v_c – speed of the saw band (m·s^{-1}),

f_{vz} – sampling frequency (Hz).

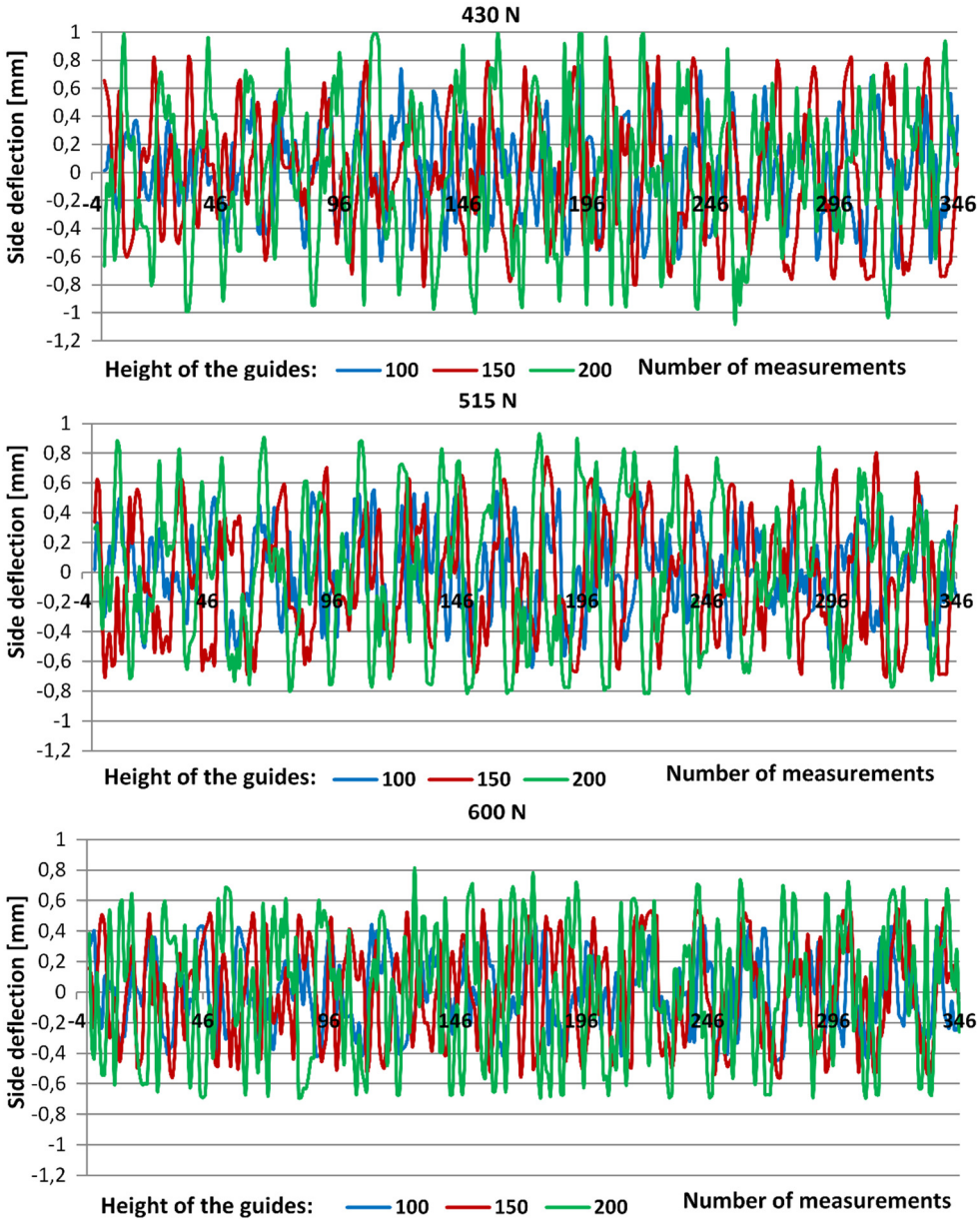


Fig. 4 The course of side deflection of the saw band depending on the height of the guides at the stretching force F_n = 430, 515, 600 N

The selected values were the basis for the assessment of the impact of the given factors on the side deflection of the band, as well as on its stability and rigidity. We compared the average values of the absolute values of the side deflection during 1 revolution of the band in all measurement evaluations (Fig. 4). Impact of stretching force on the side deflection of the saw band Fig. 5 shows the impact of stretching force on the side deflection of the band at all heights of the guides.

The theoretical hypothesis has been confirmed that stretching force has an impact on the side deflection of the saw band of a joinery band saw. Based on the obtained results it can be concluded that with increasing intensity of stretching force, the side deflection of the band is decreasing at all heights of the guides (Fig. 5).

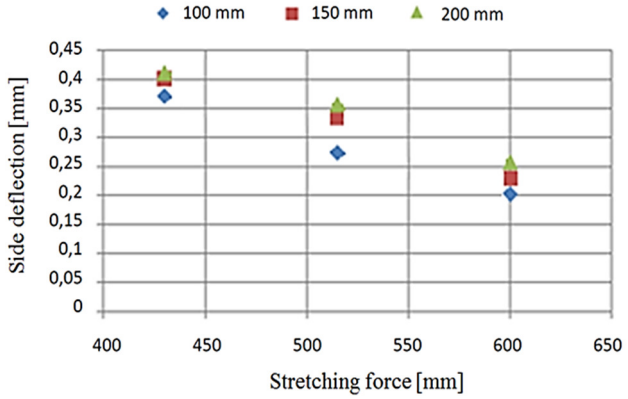


Fig. 5 Impact of stretching force on the side deflection of the band at all heights of the guides

Impact of the height of the guides on the side deflection of the saw band

The theoretical hypothesis has been confirmed that the height of the guides has an impact on the side deflection of the saw band of a joinery band saw.

Based on the results obtained (Fig. 6) it can be concluded that with increasing height of the guides, the side deflection of the band is increasing at all stretching forces.

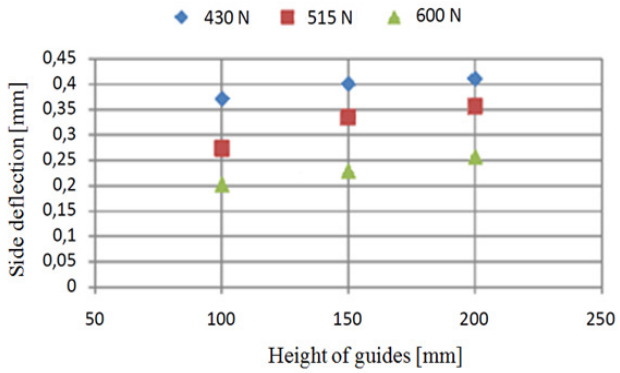


Fig. 6 Impact of the height of the guides on the side deflection of the band at all stretching forces

DISCUSSION

Stability of a saw band is the ability to withstand the force effects that tend to deflect a band away from the section plane and thus cause an uneven cut [5]. The results confirmed the hypothesis that the increasing tension in the saw band improves its stability. This fact was also confirmed by Siklienka (2004), where the results of practical tests showed an improvement of the standard deviation in the timber dimensions with increasing tension of the band [15]. The higher the tension of the band, the better the stability of the band. At lower tension, the saw band falls off the discs, at too high tension, the band begins to tear at the joints or at the bottom of a tooth gap [4]. In this paper, we were dealing with the stability of the saw band affected by stretching force as well as the height of the guides; however, we should not forget to the significant impact of the thickness of the band on its stability, and thus on the side deflection, too. The stability increases with increasing thickness of the band. The higher the tension of the band, the smaller the influence of the thickness on its stability. Siklienka 2004 claims that if the thickness of the band decreases and the tension increases, its stability will keep the same or even improve and the timber loss will be smaller [12]. Kremleva 2016 defines the tension force of the saw blade as a function parameter describing the dynamic stability [10]. Tensions along with the sliding force and spindle speed also have a significant impact on the vibration of the band saw [11, 12, 13].

The influence of the cutting speed is less pronounced at the larger cutting heights than at the smaller ones [2]. Describes the influence of tension on vibration frequencies by means of a mathematical model and graphics methods. The stability of the saw band affects the quality of the surface to be treated, thus saving the cost of machining the workpiece and making work productivity more efficient.

CONCLUSIONS

A decrease of the saw band stability causes vibration that leads to side deflection resulting in cutting deviations, surface roughness, wear and the deformation of the band. All the acquired theoretical and practical knowledge about the side deflection of the saw band show that it is a complex process. The primary objective of the paper were to measure and evaluate the impact of the selected technical and technological factors – the height of the adjustable guides and stretching force – on the side deflection of the saw band of a joinery band saw. The intensity of stretching force was chosen based on the maximum permissible tensile stress of the band set by the manufacturer and the heights of the guides were chosen based on the parameters of the machine. The measurements were carried out at cutting rate v_c = 15 m·s−1. The results of the measurements of the saw band stability confirmed the theoretical hypothesis that the side deflection decreases with increasing stretching force. The impact of the height of the guides on the saw band stability has been confirmed as well - the side deflection increases with increasing height of the guides. The change of stretching force has twice as much impact on the side deflection as the change of the height of the guides. Given the importance of the issue of the side deflection, it is necessary to supplement the gained knowledge with new information and thus be extended and enhanced.

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