

# MONITORING THE TECHNICAL CONDITION OF THE DEVICE USING THE VIBRATION DIAGNOSTIC METHOD

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Vibrations are one of the important monitored parameters, which allow acquiring primary information about the operating condition of the device. It is necessary to bear in mind that vibrations of rotating machines are closely linked to the dynamic stress of the parts like bearings or transmissions. The paper is dealing with the issue of monitoring and diagnosing the size of the two based parameters of vibrations, namely speed and vibration acceleration. The experimental section presents the results of the measurement. During the processing, we have measured the size of vibration at four places and the processing was done under varying spindle rotation speed. The conclusion presents recommendations for input factors used during measuring and processing. Here you should describe the paper idea in short.

## KEYWORDS

diagnostics, technical condition, vibration parameter, speed vibration, vibration acceleration

## 1 INTRODUCTION

All machining devices create mechanical vibrations during their operation. Increased values of vibrations have a negative impact on the technical condition and operating condition of the device. This leads to unexpected breakdowns, which lead to subsequent downtimes of the devices [Nandi 1999]. Therefore it is necessary to monitor the technical condition of the device. Monitoring the technical condition using the vibration diagnostics is an essential precondition of the operation of devices based on actual condition [Lee 2007, Cameron 1986]. The knowledge of the actual condition allows defining the extent of the necessary repairs in greater detail, exclude unnecessary revisions and subsequently save financial resources spent directly to carry out revisions; as well as resources consumed during the running in of the equipment and extend the lifespan of the device [Hetmanczyk 2014, Reilly 2011]. The fundamental principle of vibration diagnostics consists in thorough and proper measurement and analysis of mechanical vibrations of the device and its components [Krenický 2008]. The measured places are picked so that the transmission of vibrations would be dampened as little as possible, which means as close to the component that is the source of the vibrations [Panda 2016, Mascenik 2016]. In our case, we have chosen four measuring areas to monitor the size of the vibrations, specifically the head of the drilling machine, work-piece, support, and construction of the device. For a successful measurement, evaluation and monitoring of the size of the vibrations, we have ensured measurement at individual

measuring areas under the exact same conditions. Rotation speed of the spindle has been changed in four levels.

## 2 CONDITIONS OF THE MEASUREMENTS

Individual measurements have been carried out under operational conditions on a horizontal drilling machine, type TOS WHN 9B. The goal was to monitor the size of the two basic parameters of vibrations, specifically the speed and acceleration of vibrations.

The material processed during the processing was structural steel, type STN 12 060 with  $\varnothing$  110 mm and the rotation speed of the spindle changed in four levels, specifically 224 rpm, 280 rpm, 400 rpm and 560 rpm. The movement during the processing was constant 20 mm/min. The measurement was carried out at four areas selected in advance - the head of the drilling machine (fig. 1), work-piece (fig. 2), support (fig. 3) and construction of the machine (fig. 4). All measurements have been repeated 3 times and the weighted arithmetic mean (WAM) has been calculated based on the measured data, which was then used to draw graphic dependencies.

The CMMS CHECKER device with a multiparametric sensor mounted at individual measuring areas using a magnet has been used to measure basic parameters of vibrations.

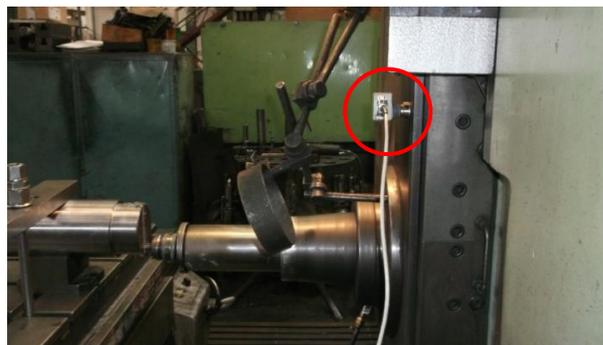


Figure 1. Measurement of vibration at the drilling machine - sensor measures vibrations perpendicularly to the surface, probably



Figure 2. Measurement of vibration at the work-piece

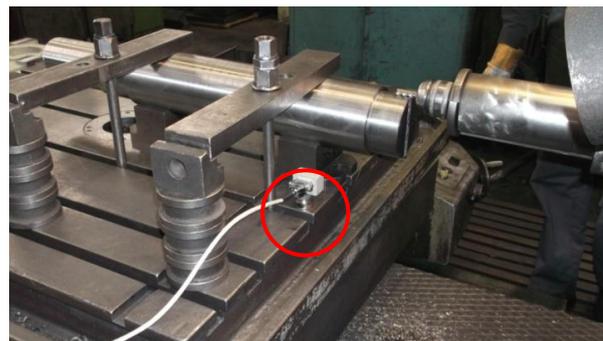


Figure 3. Measurement of vibration at the support



Figure 4. Measurement of vibration construction of the machine

### 3 ANALYSIS OF MEASURED DATA

The processing of measure data consisted in evaluating weighted arithmetic means from individual repetitions of measurements, individually for four measured areas.

Calculated values of the weighted arithmetic mean and measured values of the two parameters of vibrations are depicted in Tab. 1 through Tab. 4, individually for all measuring areas. Subsequently the graphic dependencies in Fig. 5 through Fig. 8 show the values of speed and acceleration of vibrations depending on the rotation speed of the spindle drill head individually for all measuring areas.

Table 1. The values of weighted arithmetic mean at the measured area – head of the drilling machine

rotation speed of the spindle [rpm]	parameters of vibration	
	the vibration speed v [mm/s]	acceleration of vibrations a [g]
224	0.4	0.5
280	0.9	1.1
400	1.4	2.3
560	2.8	3.1

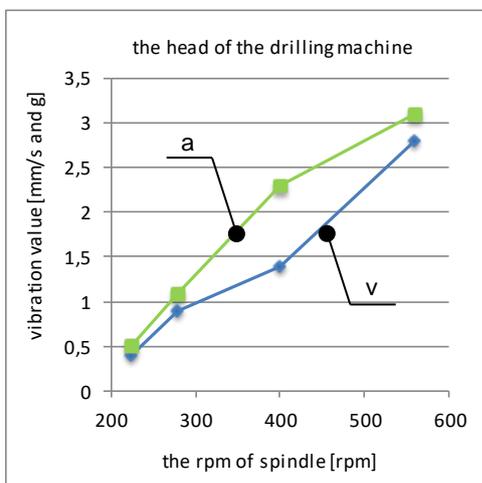


Figure 5. Graphical dependency of the parameters of vibrations on the rotation speed of the spindle when measuring at the head of the drilling machine

When processing steel and measuring the parameters of vibrations on the head of the drilling machine, increasing the value of rotation speed of the spindle increases the values of vibrations. The values of vibration acceleration grow in the range from 0.5 g at 224 rpm to 3.1 g at 560 rpm. The graphic dependency in Fig. 5 shows an acceleration of 3.1 g at maximum speed of 560 rpm, lowest value of 0.5 g at 224 rpm; so the acceleration curve has an increasing trend. The lowest speed of 0.4 mm/s is at 224 rpm. The highest value of vibration speed on the head of the spindle is at 560 rpm, specifically 2.8 mm/s.

Table 2. The values of weighted arithmetic mean at the measured area – work-piece

rotation speed of the spindle [rpm]	parameters of vibration	
	the vibration speed v [mm/s]	acceleration of vibrations a [g]
224	0.3	0.7
280	0.7	1.5
400	1.3	2.1
560	1.9	2.6

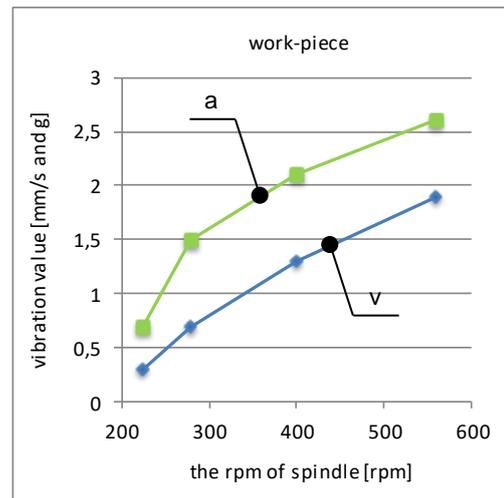


Figure 6. Graphical dependency of the parameters of vibrations on the rotation speed of the spindle when measuring on the work-piece

When processing steel and measuring the parameters of vibrations at the work-piece, while changing the input technological parameter - rotation speed of the spindle, speed values rise in the range of 0.3 mm/s at 224 rpm to 1.9 mm/s at 560 rpm. The progress of acceleration values when changing the rotation speed is described by the acceleration curve. Acceleration of 0.7 g was achieved at 224 rpm. Increase of the rotation speed increases the acceleration values as well, whereby at 560 rpm acceleration grew to 2.6 g.

Table 3. The values of weighted arithmetic mean at the measured area – support

rotation speed of the spindle [rpm]	parameters of vibration	
	the vibration speed v [mm/s]	acceleration of vibrations a [g]
224	0.1	0.3
280	0.4	0.6
400	0.7	1
560	1.2	1.4

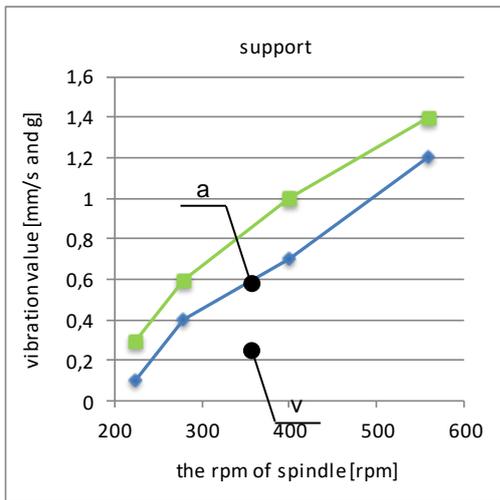


Figure 7. Graphical dependency of the parameters of vibrations on the rotation speed of the spindle when measuring at the support

The speed and vibration acceleration curve grows depending on the change of rotation speed. At 224 rpm, the vibration speed is 0.1 mm/s, this is the lowest value. The highest value of vibration speed of 1.2 mm/s can be observed in the graphical dependency (Fig. 7) at 560 rpm. The lowest acceleration of vibrations of 0.3 g can be seen at 224 rpm. The curve reaches the maximum value of vibration acceleration at 560 rpm, specifically 1.4 g.

Table 4. The values of weighted arithmetic mean at the measured area – construction of the device

rotation speed of the spindle [rpm]	parameters of vibration	
	the vibration speed v [mm/s]	acceleration of vibrations a [g]
224	0.3	0.6
280	0.5	0.9
400	0.6	1.3
560	1.1	1.9

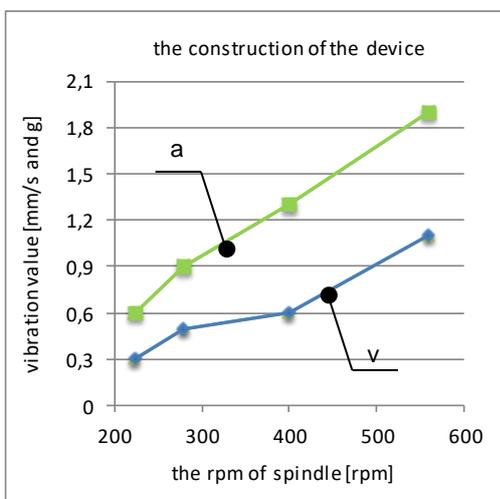


Figure 8. Graphical dependency of the parameters of vibrations on the rotation speed of the spindle when measuring at the construction of the device

The graphic dependency in Fig. 8 shows curves with an increasing character. The vibration speed has the lowest value

at 224 rpm, specifically 0.3 mm/s. Gradually increasing the rotation speed of the spindle increases the value of the vibration speed. The maximum vibration speed was at 560 rpm, specifically 1.1 mm/s. The lowest acceleration value of 0,6 g was achieved at 224 rpm. On the other hand, the highest acceleration value of 1.9 g was recorded at 560 rpm.

The evaluation of the measured values included also the creation of comparison covers of both observed parameters of vibrations individually for the examined rotation speed of the spindle 224, 280, 400 and 560 rpm. The comparison is depicted in the form of graphic dependencies in Fig. 9 – 12.

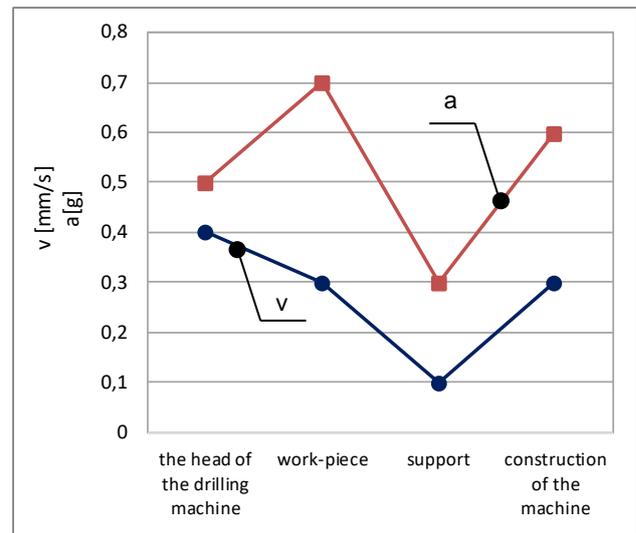


Figure 9. Comparison graph of acceleration and speed covers for spindle speed 224 rpm

When processing material at 224 rpm and said feed speed, it is possible to observe the lowest values of vibration acceleration in measured area – support (0.3 g). On the other hand, the highest value of acceleration is reached on the work-piece (0.7 g). at the same time, lowest speed was recorded on the work-piece, support and construction of the device (0.1 mm/s).

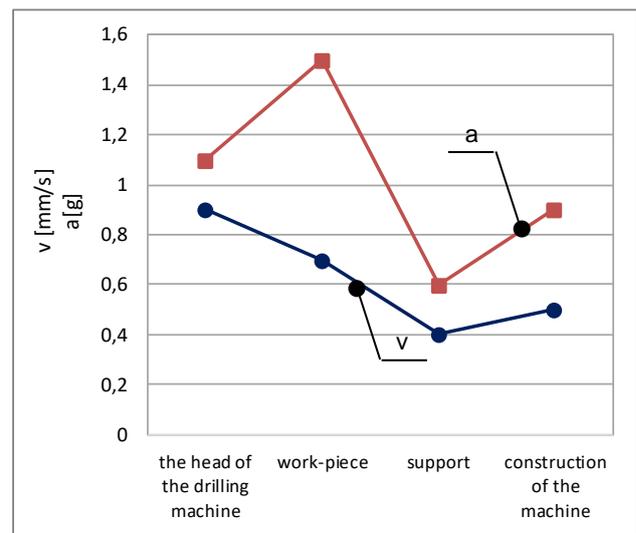


Figure 10. Comparison graph of acceleration and speed covers for spindle speed 280 rpm

At 280 rpm and constant feed speed, the graphic comparison in Fig. 10 shows the slowest vibration acceleration on the support (0.6 g). The highest value of vibration acceleration is on the work-piece (1.5 g). The vibration speed is the slowest on

support (0.4 mm/s). The highest speed is on the head (0.9 mm/s).

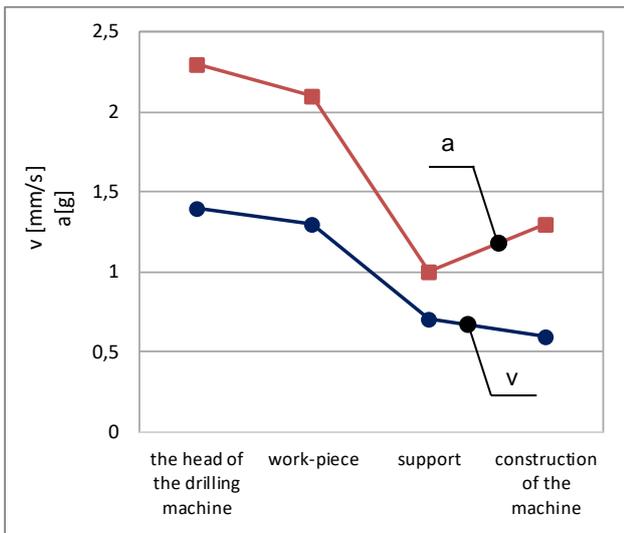


Figure 11. Comparison graph of acceleration and speed covers for spindle speed 400 rpm

The graphic dependency in Fig. 11 shows that the lowest vibration acceleration is on the support (1 g) at 400 rpm and constant feed speed. The greatest acceleration (2.3 g) is recorded on the work-piece. The slowest vibration speed (0.6 mm/s) is on the construction of the machine; the highest speed (1.4 mm/s) was on the head.

In graphic comparison in Fig. 12 the highest acceleration (3.1 g) is on the head. The lowest vibration speed (1.1 mm/s) is on the construction of the machine and the electromotor. On the other hand, the highest vibration speed (2.8 mm/s) is on the head.

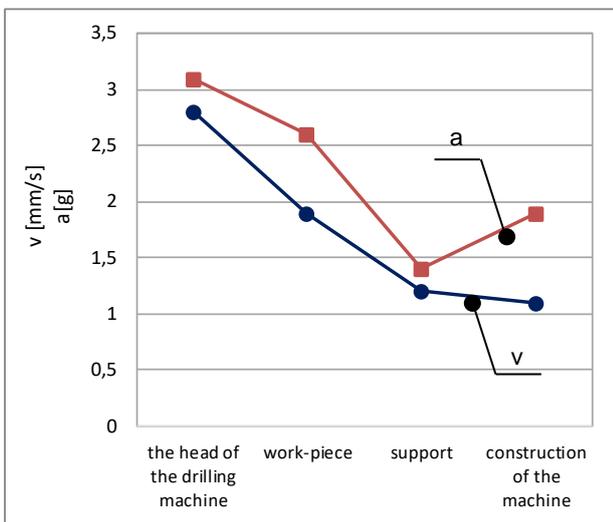


Figure 12. Comparison graph of acceleration and speed covers for spindle speed 560 rpm

#### 4 CONCLUSION

The evaluation of the experiments show that increasing the speed of the drilling machine head increases the values of the speed and acceleration of the vibrations. The highest measured values of the speed and acceleration of vibrations were achieved at 560 rpm. With long-term use of this spindle

rotation speed the vibrations could negatively affect the span, tear and wear, and economic efficiency of the machine. The analysis also shows that when using other spindle rotation speeds of 224 rpm, 280 rpm and 400 rpm, measured values of both vibration parameters are in the normal range and there is no likelihood of an early occurrence of malfunction on the TOS WHN 9B device. The measurement shown that vibration diagnosis is an effective tool to examine the technical condition of devices. However, several measurements have to be carried out for a more detailed diagnosis of the defect, and they have to be mutually compared between each other.

The obtained results can be applied in work of engineers and designers, in the design of technological procedures for various parts, in determining wear and tear, when selecting the suitable processing technology and to determine suitable input technological conditions of the chosen technology, as well as decreasing downtimes caused by defects.

#### ACKNOWLEDGMENTS

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