

Analysis of lathe vibration severity level based on spindle rotation speed variations referring to the ISO 20816-3 standard

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ABSTRACT

Vibration is an important parameter in monitoring machine condition because each rotating component produces a certain vibration pattern. Vibration frequency can identify mechanical damage before it develops into more serious damage. This study aims to analyse the vibration severity of the Weiler Gedee lathe, which is categorised as group 2 with a nominal power of more than 15 kW to 300 kW, using the ISO 20816-3 standard to evaluate machine condition. The research uses an experimental method to measure vibration with a vibration meter; the values obtained represent the maximum values in the horizontal, vertical, and axial directions. The rotation speeds used are 60 rpm, 120 rpm, 330 rpm, 450 rpm, 660 rpm, and 900 rpm. The average vibration values obtained are 0.55 mm/s, 0.98 mm/s, 1.87 mm/s, 2.11 mm/s, 3.63 mm/s, and 5.32 mm/s. Based on the ISO 20816-3 classification, the condition of the machine at 60-120 rpm is in zone A which means very good, 330–450 rpm is in zone B which is still suitable for operation, at 660 rpm it has entered zone C which indicates a warning condition for long-term operation, while at 900 rpm the highest vibration value is obtained which is in the dangerous zone D. It can be concluded that the vibration level of the machine is influenced by variations in spindle rotation and the higher the rotation, the greater the measured vibration level.

Keywords: lathe; Vibration; Velocity RMS; ISO 20816-3

INTRODUCTION

The rapidly developing manufacturing industry demands machine tools with high precision, productivity, and reliability. (Trihatmanto & S, 2024) says that one machine tool that plays an important role in the manufacturing process is the lathe. Lathes are used for various

metalworking processes such as cylindrical turning, taper turning, thread making, drilling, and various other machining processes. The quality of products produced by lathes is greatly influenced by the operational conditions of the machine, including the stability of the mechanical system during the

machining process according to (Zaira, 2025).

Research conducted by (Alhaffis, 2020) states that excessive vibration in lathes can negatively affect the production process and the machine's lifespan. From a product quality perspective, vibration can cause cutting vibrations that result in rough workpiece surfaces, dimensional inaccuracies, and decreased geometric quality of the machining results. From an equipment perspective, high vibrations can accelerate tool wear, damage bearings, shorten the life of transmission components, and increase the risk of sudden machine failure (Agung et al., 2026). One of the most widely used predictive maintenance methods is vibration analysis. This method allows periodic monitoring of machine conditions by measuring vibration parameters, so it can detect early signs of damage before more serious failures occur. Thus, maintenance costs can be reduced, and production downtime can be minimised (Ari Togar Maulana, 2026).

Vibration analysis is generally carried out by measuring three main parameters, namely displacement, vibration velocity, and vibration acceleration. Among these three parameters, RMS (Root Mean Square) velocity is the most widely used parameter to evaluate the overall severity of machine vibration because it describes the vibration energy over a wide frequency range. Therefore, various international standards use the RMS velocity parameter as a basis for assessing machine condition (Widyanto & Widodo, 2024). One of the international standards currently

used as a reference in evaluating vibration severity is ISO 20816-3 (Nur Asaf Abdullah, 2023). ISO 20816-3 groups vibration severity into several condition zones: Zone A, Zone B, Zone C, and Zone D. Each zone indicates the level of machine health, ranging from very good condition to conditions that have the potential to cause serious damage. Spindle rotational speed is one operational parameter that strongly influences a lathe's vibration characteristics. (Susanto & Kido, 2026) argues that higher spindle rotation generates greater centrifugal force in the rotating components. Based on the description, it is necessary to conduct research aimed at determining the relationship between variations in spindle rotation speed and the resulting vibration level, determining the classification of machine conditions based on the ISO 20816-3 standard, and providing information on the operational limits of lathes that are still in a safe and usable condition. The results of this research are expected to be a reference for academics, technicians, and industry in implementing a more effective machine condition monitoring system to improve the reliability, efficiency, and service life of lathes.

METHODOLOGY

This study uses a quantitative experimental method by directly testing the machining process to determine the relationship between changes in spindle rotation and machine vibration characteristics and severity, based on the ISO 20816-3 standard. This study was conducted in the machining workshop of the

machine maintenance engineering study program, AK-Manufaktur Bantaeng, which served as a site for material preparation, research equipment for lathe machining processes, and vibration data collection. The laboratory area is equipped with a ventilation system and work safety measures in accordance with the Standard Operating Procedure (SOP) for tool use. The tools used in this study support the data collection process to obtain optimal research results, including conventional lathes, HSS chisels, Lutron VT-8204 type vibrometers, laptops, lathe toolsets,

and personal protective equipment. This study used ST 60 steel, which was mounted on a lathe as the workpiece. ST 60 steel was chosen because it has good strength and hardness characteristics and is widely used in machine components. This material provides loading conditions close to real applications so the vibration data can more accurately reflect the machine's operating conditions. In addition, supporting materials such as lubricants and cleaning fluids are used to maintain the machine's working condition during data collection.



Figure 1. Tools and materials used for data collection

The main objective of the turning process in this study is not only to produce machined products, but also to determine how changes in spindle rotation affect the lathe's vibration level during operation. Therefore, the main focus is the variation in machine spindle rotation. According to research from (2019), before the turning process, the lathe is inspected

to ensure all components are in good condition and suitable for use. Next, the workpiece is mounted on the lathe chuck and clamped firmly to prevent slippage during machining. The lathe tool used is an HSS tool, which is mounted on the tool post, and its height is adjusted to align exactly with the workpiece centreline. argues that inaccurate tool installation can

cause cutting instability, which increases vibration. In the lathe testing process, spindle rotation variations were carried out to determine the vibration characteristics produced at each operating condition. The rotation variations used consisted of 60 rpm, 120 rpm, 330 rpm, 450 rpm, 660 rpm, and 900 rpm. Rotation measurements were carried out using a tachometer, and machine vibration was measured to obtain vibration data at each rotation speed. Before the main test, we measured the actual vibration value at each rotation speed as baseline data. The measurement results showed that at 60 rpm the actual vibration value was obtained at

0.32 mm/s, while at 120 rpm it was 0.75 mm/s. Furthermore, at 330 rpm the vibration value was obtained at 1.67 mm/s, at 450 rpm it was 1.92 mm/s, and at 660 rpm it was 3.49 mm/s. Each rotation variation was run separately so that its effect on vibration levels could be clearly observed. During turning, other cutting parameters, such as the depth of cut (0.1 mm) and feed rate (0.1 mm/turn), were kept constant.

Vibration data collection is carried out to obtain information regarding the vibration characteristics that occur in the lathe during the operating process according to (Abdillah, 2023).



Figure 2. Turning process and vibration data collection

The data obtained is then used to determine the vibration severity level based on the classification in the ISO 20816-3 standard. Figure 3 below

shows the method for evaluating the machine's severity level based on ISO 20816-3.

Table 1. ISO 20816-3 standard vibration severity rating method

Grupo 2: Máquinas con potencia 15 - 300 kW Máquinas eléctricas 160<H<315		Grupo 2: Máquinas con potencia 300 kW 40MW Máquinas eléctricas H>315	
Base Rígida	Base Flexible	Base Rígida	Base Flexible
0,7 A	A	A	A
1,4 B			
2,3 C			
2,8 C	B	B	B
3,5 D			
4,5 D	C	C	B
7,1 D	D	D	C
11 D			D

The Lutron VT-8204 vibrometer calibration process was carried out at the Machining Workshop on January 13, 2026. Calibration ensured the instrument had sufficient accuracy and reliability before being used to measure vibration on a lathe. The vibrometer calibration method followed the manufacturer's calibration point, set at 160 Hz. The Lutron VT-8204 vibrometer has several measurement parameters: for vibration velocity, the range is 0.5–199.9 mm/s; for acceleration, it is 0.5–199.9 m/s². For displacement, the measurement range is 0.005–1.999 mm. Based on the manufacturer's specifications, the Lutron VT-8204 vibration measurement accuracy is $\pm (5\% + 2 \text{ digits})$ of the reading at 80 Hz

and 160 Hz, with ambient conditions of $23 \pm 5 \text{ }^{\circ}\text{C}$. The Lutron VT-8204 vibrometer's measuring frequency range is 10 Hz to 1 kHz (1,000 Hz).

Vibrometer sensors are placed at several measurement points during lathe vibration measurement to represent the machine's main components. At each point, measurements are made in three directions: axial, horizontal, and vertical. Axial measurements are made by placing the sensor parallel to the spindle rotation axis. Horizontal measurements are made by placing the sensor horizontally or perpendicular to the spindle axis, while vertical measurements are made by placing the sensor perpendicular to the machine base plane, as shown in the image below.

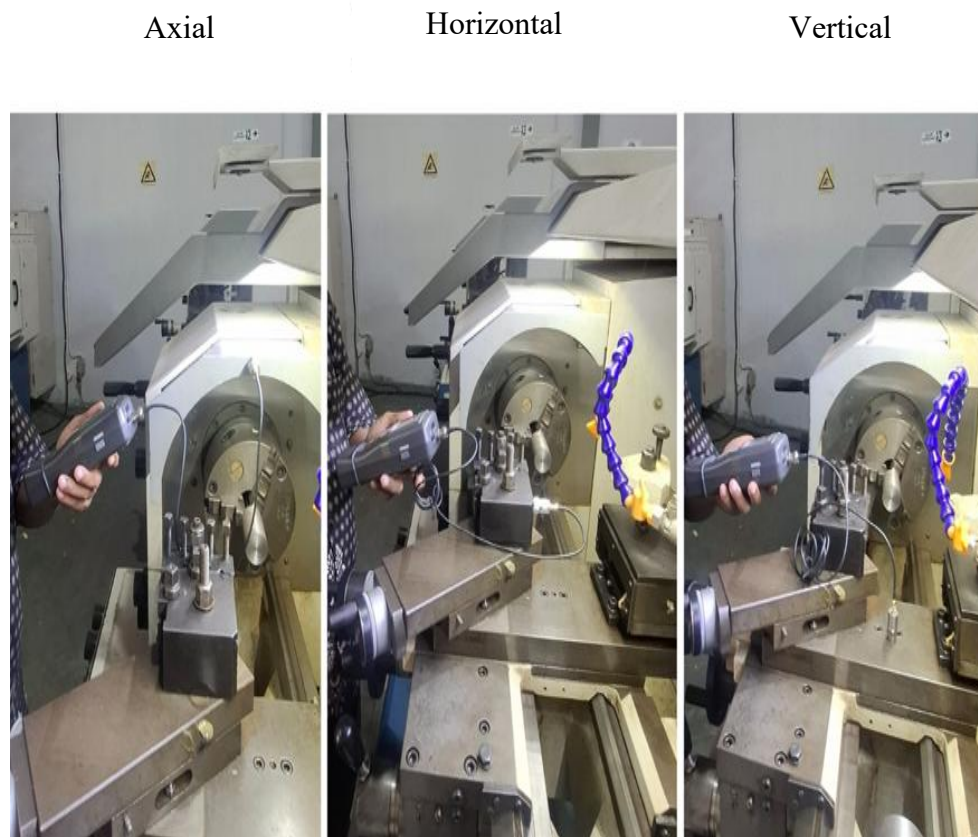


Figure 3. Vibrometer sensors are placed on the lathe

Vibration data collection is carried out to obtain information on the vibration characteristics that occur in the lathe during operation. The data obtained is then used to determine the vibration severity level based on the classification in ISO 20816-3. The vibration measurement method uses a vibration meter capable of measuring vibration parameters such as

acceleration, velocity, and displacement. However, for machine severity evaluation based on ISO 20816-3, the most commonly used parameter is the RMS vibration velocity value (mm/s).

Figure 2. ISO 20816-3 zone boundaries on Gedee Weiler lathes

Machine Group	Seat Condition	Zona A (Very Good)	Zona B (Good)	Zona C (Alert)	Zona D (Danger)
Group 2 (>15–300 kW)	Rigid	$\leq 1,4$ mm/s	$>1,4-2,8$ mm/s	$>2,8-4,5$ mm/s	$>4,5$ mm/s
Group 2 (>15–300 kW)	Flexible	$\leq 2,3$ mm/s	$>2,3-4,5$ mm/s	$>4,5-7,1$ mm/s	$>7,1$ mm/s

The table shows the vibration severity limits based on ISO 20816-3 for a Gedee Weiler lathe under the specified machine mounting conditions. can be used as a reference for assessing vibration levels. Lathes categorised as Group 2 have a nominal power of more than 15 kW up to 300 kW. This grouping is used to determine vibration evaluation limits that are appropriate to the characteristics.

Before data collection, calibrate the vibration meter to ensure accurate measurement results. After calibration, the vibration sensor is placed at the predetermined measurement point. The vibration data analysis process is carried out after all the vibration measurement data from the lathe machining process has been collected. (Amin & Hajar, 2013) argues that analysing data with RMS velocity can effectively assess the vibration velocity signal obtained during a certain measurement period. RMS velocity describes the overall vibration severity of a machine during

a measurement interval. Because the RMS value relates to the energy content of the vibration signal, a higher RMS velocity indicates a higher vibration energy level produced by the system. Therefore, RMS velocity provides an effective measure of overall vibration severity during the measurement process. Mathematically, RMS Velocity is expressed as follows.

$$V_{RMS} = \sqrt{\frac{1}{T} \int_0^T v^2(t) dt} \quad (1)$$

Where V_{RMS} value is the RMS vibration velocity (mm/s), $v(t)$ is the instantaneous vibration velocity, and T is the measurement period. The equation shows that the entire vibration signal is first squared, then averaged over the measurement time interval, and then squared according to (Bagasworo & Machfuroh, 2026). This process produces a single value that represents the overall vibration energy level. The waveform produced by a vibration meter is a representation of the vibration signal of a machine or structure over time, according to (Lesmana et al., 2022).

This waveform describes how the vibration amplitude changes during the measurement period and is an important parameter in analyzing machine conditions. (Prakarsa Ade Putra Surbakti, 2021) argues that the data displayed by the vibration meter comes from a vibration sensor that converts mechanical movement into an electrical signal, which is then processed into vibration parameters such as displacement, velocity, and acceleration. In a machine that is operating normally, the waveform tends to be periodic and approaches sinusoidal because the main source of vibration comes from the rotation of the shaft or components that move regularly. A stable waveform indicates that the vibration energy is evenly distributed and there is no significant mechanical disturbance. The vibration waveform can be described by a simple harmonic vibration equation, such as the following equation.

$$x(t) = A \sin(\omega t + \phi) \quad (2)$$

Where $x(t)$ is the vibration deviation with respect to time, A is the vibration amplitude, Ω is the angular frequency (rad/s), t is the time, and ϕ is the phase angle. This equation shows that the vibration amplitude changes periodically over time, forming a specific wave pattern. Under ideal

conditions, the waveform appears smooth and repeats consistently.

RESULT AND DISCUSSION

This study aims to analyze the effect of spindle rotation variations on the severity of lathe vibration based on the Velocity RMS (mm/s) parameter, referring to the ISO 20816-3 standard. Before the main test was carried out, the actual vibration value was measured as initial data with the rotation variations used consisting of 60 rpm, 120 rpm, 330 rpm, 450 rpm, 660 rpm, and 900 rpm at each rotation variation, then the turning process with other cutting parameter loads such as a cutting depth of 0.1 mm, a feed rate of 0.1 mm/rotation, the type of tool used was HSS, and the workpiece material was ST 60 steel with a diameter of 50 mm and the same rotation variations as in the initial data collection. The first stage of data collection is carried out at a spindle rotation of 60 rpm. After the rotation reaches a stable condition, vibration measurements are carried out using a vibration meter and the vibration value is recorded. This low rotation is used as a baseline condition to determine the level of machine vibration at minimum speed. The data collection process and vibration waveform at a spindle rotation of 60 rpm can be seen in the figure below.

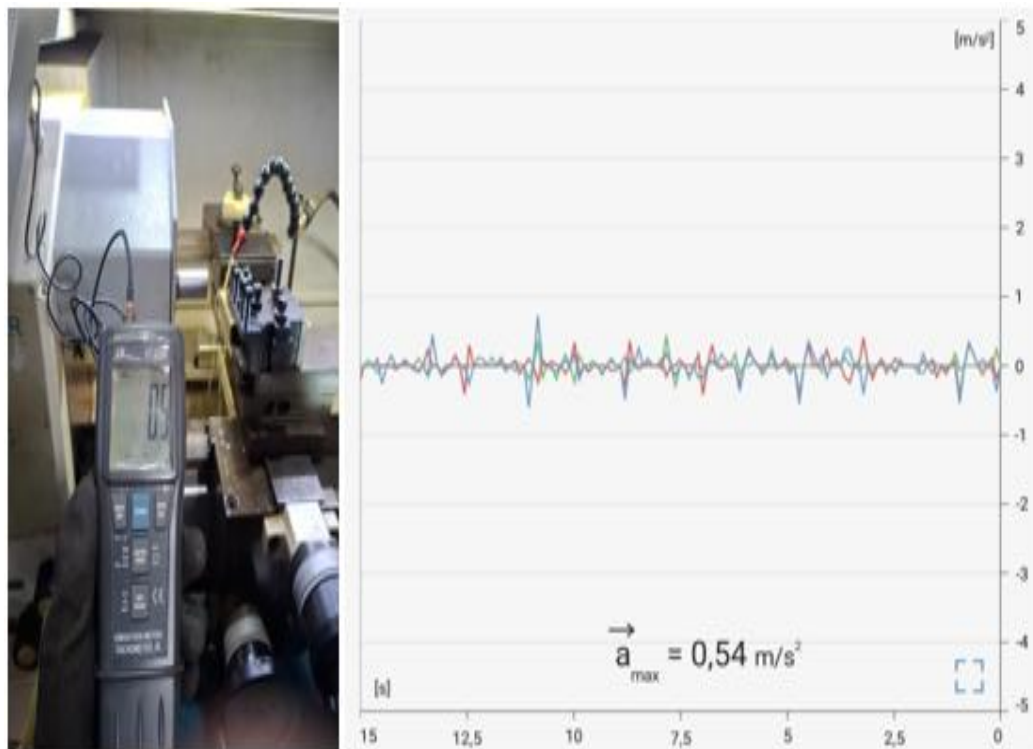


Figure 4. Data acquisition and vibration waveform at 60 rpm spindle

The next step was carried out at 900 rpm, the highest speed in this study. After the spindle speed reached the specified value and the operating conditions had stabilised, vibration measurements were taken and the results recorded. At high speeds, the centrifugal force generated is directly proportional to the square of the angular velocity, so that small imbalances in the system can produce much larger vibrations (Simarmata, Firman Paniroi, Tomi Abdilah, 2026). Therefore, the vibration value obtained at 900 rpm is generally the highest value compared to other speeds. The measurement results show that increasing spindle rotation increases the vibration value in the lathe. Research conducted by (Simarmata, Firman Paniroi, Tomi Abdilah, 2026) states that this phenomenon occurs because the

higher the spindle rotation, the greater the dynamic force generated by the rotating system, whether due to mass imbalance, centrifugal force, friction between components, or excitation that occurs during the turning process. The next stage in data processing is to collect vibration measurement data at each spindle-speed variation. Before further analysis, all data are checked to ensure they are valid and usable. After the data is declared valid, the next step is to calculate the average value for each rotation variation using the following formula.

$$\bar{x} = \frac{x_1 + x_2 + x_3}{3} \quad (3)$$

From the results using the formula above, the calculation results at a spindle rotation speed of 60 rpm with data obtained from direct measurements, namely 0.54 mm/s,

0.56 mm/s, and 0.55 mm/s, are 0.55 mm/s and the complete results can be seen in the table below.

Table 3. RMS vibration speed

Spindle Speed (rpm)	Horizontal (mm/s)	Vertical (mm/s)	Axial (mm/s)	Mean RMS Velocity (mm/s)
60	0,54	0,56	0,55	0,55
120	0,96	0,97	1,01	0,98
330	1,84	1,86	1,91	1,87
450	2,10	2,17	2,06	2,11
660	3,64	3,62	3,63	3,63
900	5,30	5,31	5,35	5,32

The data above represent the RMS velocity values obtained directly from a vibration meter or vibration analyser. This result represents a representative RMS velocity value at 60 rpm. To determine the vibration level between revolutions, calculate the percentage increase using the following formula.

$$\% \text{ Kenaikan} = \frac{V_2 - V_1}{V_1} \times 100\% \quad (4)$$

Where V1 is the initial RMS velocity value, and V2 is the next RMS velocity value. These results indicate that increasing the rotational speed from 60 rpm to 120 rpm results in a 78.18% increase in vibration. This increase occurs because the centrifugal force generated by the rotating components increases with increasing cutting speed. At low

rotational speeds, the machine system remains stable, so the vibrations mostly originate from minor spindle imbalances. Doubling the rotational speed significantly increases the vibration response. The following table shows the percentage increase in vibration values between spindle rotational speeds. Based on the test results, we analysed the relationship between spindle speed (rpm) and the percentage increase in vibration using second-order polynomial regression. Since the spindle speed data is given in interval form, the mean value of each interval is used as a representative value of the spindle speed. The second-order polynomial regression model with the following formula

$$Y = a + bN + cN^2 \quad (5)$$

Table 4. Vibration measurement results data and polynomial regression

Vibration between rotations (rpm)	Middle Value (rpm)	Percentage increase in vibration (%)
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60 - 120	90	78,18
120 - 330	225	90,81
330 - 450	390	12,83
450 - 660	555	72,03
660 - 900	780	46,55

Based on the analysis of the percentage increase in vibration between spindle rotations, an increase in rotation is always followed by an increase in vibration values. The largest increase occurred in the 120–330 rpm range (90.81%), while the smallest occurred in the 330–450 rpm range (12.83%). These results indicate that the relationship between spindle rotation and vibration is not completely linear. According to in several rotation ranges, the system shows a more sensitive vibration response due to the influence of the dynamic characteristics of the machine, such as structural stiffness, damping, mass imbalance, bearing conditions, and may also be associated with machine dynamic

characteristics; however, frequency-domain analysis is required to determine whether resonance contributes to the observed. Overall, the increasing percentage of vibration at medium to high rotations indicates that the dynamic energy received by the machine increases with spindle speed (Endriatno, 2022). This supports machine dynamics theory that the excitation force on a rotating system increases with rotation, resulting in a higher RMS Velocity value and greater vibration severity based on the ISO 20816-3 standard (Haris et al., 2025). This analysis helps explain how sensitive vibration is to changes in spindle rotation (Nurul & Suryanto, 2021).

Table 5. Vibration measurement results with machine conditions

Spindle speed (rpm)	Maximum (mm/s)	ISO Zone	Interpretation
60	0,55	A	Very good
120	0,98	A	Very good
330	1,87	B	Good
450	2,11	B	Good
660	3,63	C	Alert
900	5,32	D	Danger

The values in the table above represent the results of vibration

measurements. In this study, we replaced these values with

measurements from the turning process. The table shows a tendency for the RMS Velocity value to increase as the spindle speed increases. This increase indicates that

the machine structure absorbs more vibration energy at higher speeds.

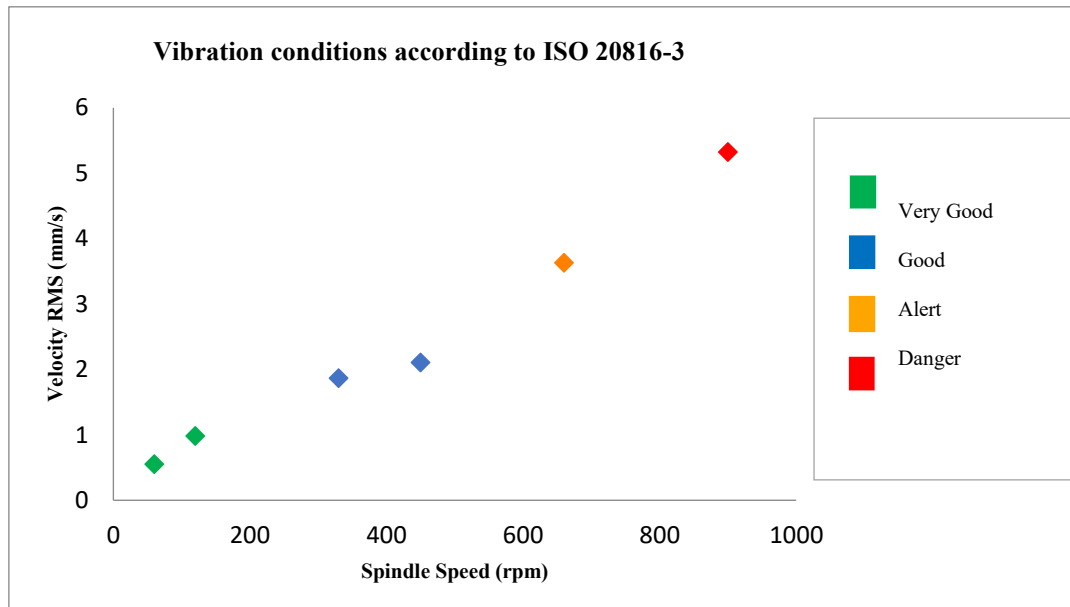


Figure 5. Vibration conditions according to ISO 20816-3

The bar chart above shows that vibration values at 60 rpm and 120 rpm are the lowest. The bars in this range are relatively short, indicating that increasing rotational speed has not yet caused a significant increase in vibration. This condition occurs because the centrifugal force generated is still small and the spindle mass imbalance has not had a significant impact. In this area, the machine operates very stably, so the vibration value is still in the safe category according to ISO 20816-3 (Hutahaeen, 2022). The vibrations are mostly normal, due to motor rotation and friction between components. The diagram shows an increase in RMS velocity from 0.98 mm/s to around 1.87 mm/s. Although the

increase is not very large, the graph shows a clearer increase than at the low rotational speed. The diagram shows a greater increase compared to the previous interval. The RMS Velocity value increases from around 2.11 mm/s to 3.63 mm/s. This increase indicates the system is entering an operating area with higher dynamic loads. Several factors cause increased friction in the bearings and increased cutting forces during the turning process (Yudistiro et al., 2026). The diagram shows a fairly sharp increase from 3.63 mm/s to 5.35 mm/s. The increasingly tall bar diagram indicates that rotation's influence on vibration is starting to dominate. The increase in rotation results in a much greater increase in

the excitation force than the increase in rotation itself (Putra et al., 2025). In this area, more dominant rotor imbalance and more rapid bearing wear can begin to appear (Akbar & Karmiadj, 2023).

Based on the presented measurement results, increasing spindle speed significantly increases lathe vibration, as shown by the velocity RMS (mm/s) parameter. The vibration value increased gradually from 0.55 mm/s at 60 rpm to 5.32 mm/s at 900 rpm. These results indicate a direct relationship between spindle rotational speed and the vibration level produced by the lathe. At 60 rpm, the measured vibration value was 0.55 mm/s and falls in Zone A under the ISO 20816-3 standard. Zone A indicates that the machine is in very good condition and is suitable for continuous operation without risk of damage (Halim et al., 2021). When the rotational speed increased to 120 rpm, the vibration value increased to 0.98 mm/s, but it is still in Zone A. This increase indicates that higher rotational speed increases the dynamic excitation force, but it is not large enough to cause a worrying vibration condition (Aditiya, 2021). The machine still shows very good performance with a high level of operational stability (Mahdan & Yudo, 2025). The effect of medium speed on vibration levels. At 330 rpm, the RMS Velocity value increases to 1.87 mm/s and moves to Zone B. This condition is still categorised as good and acceptable for long-term operation. However, the move from Zone A to Zone B indicates that the increase in spindle speed begins to have a more significant impact on the machine's dynamic behaviour

(Aditiya, 2021). A further increase at 450 rpm results in a vibration value of 2.11 mm/s, which is still in Zone B. Although the increase in vibration is not large compared to the previous rotation, the upward trend remains visible. This indicates that the system's increasing kinetic energy gradually raises the vibration amplitude. The effect of high speed on vibration levels. At 660 rpm, the vibration value increases significantly to 3.63 mm/s and enters Zone C. According to ISO 20816-3, Zone C indicates that the machine condition requires special attention because the vibration level has reached a limit that can affect the service life of machine components if left to operate for a long period. The significant increase in vibration at this rotation indicates that the dynamic excitation force due to the imbalance of the rotating mass is becoming more dominant. At the highest rotation of 900 rpm, the vibration value reaches 5.32 mm/s and enters Zone D. Based on ISO 20816-3, Zone D indicates a dangerous vibration condition and is not recommended for continuous operation. This value indicates the machine may be at risk of damage due to the high dynamic load on the system. High vibration at 900 rpm can be caused by spindle mass imbalance, which becomes more pronounced at higher speeds, bearing wear that produces additional vibration forces, and misalignment between transmission components. A dominant peak at $1 \times \text{RPM}$, especially if its amplitude is high and stable across speed changes, often indicates imbalance. Imbalance occurs when the rotor's centre of mass does not coincide with its axis of rotation. As

the rotor rotates, it generates periodic centrifugal forces that cause vibration at a frequency equal to the rotational speed. However, $1 \times \text{RPM}$ does not necessarily indicate unbalance. Misalignment, eccentricity, a bent shaft, or other problems can also produce components at this frequency. Therefore, diagnosis should use a combination of spectrum, phase, measurement direction, and operating conditions.

CONCLUSION

Based on the measurement results, data processing, analysis of RMS Velocity values, and evaluation of vibration severity based on the ISO 20816-3 standard, increasing the spindle speed on a lathe can affect the measured RMS vibration level. The RMS vibration increases from 0.55 to 5.32 mm/s as the spindle speed increases from 60 to 900 rpm. Based on the selected ISO category, there is a shift from Zone A to Zone D. The relationship between rpm and vibration is non-linear; therefore, frequency domain analysis is needed to identify the underlying mechanism. This condition indicates that at low speeds, the excitation force acting on the system is still relatively small so that the resulting vibration amplitude is also low. Low speeds provide the smallest vibration severity compared to other rotation variations. The percentage increase in vibration shows a fluctuating increase pattern; the results of the analysis of the percentage increase in vibration show that the increase in vibration between rotations does not occur linearly. The percentage increase at 60 rpm-120 rpm was 78.18%, at 120 rpm-330 rpm was 90.81%, at 330 rpm-450 rpm was

12.83%, at 450 rpm-660 rpm was 72.03%, and at 660 rpm-900 rpm was 46.55%. The largest increase occurred in the 120 rpm-330 rpm range (90.81%), while the smallest increase occurred in the 330 rpm-450 rpm range (12.83%). These results indicate that the machine's vibration response is influenced not only by increased spindle speed but also by the system's dynamic characteristics.

REFERENCES

- Abdillah, H. (2023). Analisis Standar Getaran Mesin Gerinda Duduk Berdasarkan ISO 2372 Akibat Variasi Material Benda Kerja ISSN 2549-2888 Jurnal Teknik Mesin: Vol . 12 , No . 3 , Oktober 2023 ISSN 2549-2888. *Teknik Mesin*, 12(3), 206–211.
- Aditiya, N. A. (2021). Pengaruh Kedalaman Pemakanan Pada Mesin Frais Terhadap Getaran dan Kekasaran Permukaan Baja Aisi 4140. *JTME (Jurnal Teknik Mesin Dan Energi)*, 1(02), 1–8.
- Agung, A., Yonico, W., Napitupulu, R., & Pranandita, N. (2026). Analisis Hubungan Getaran dan Kualitas Kebulatan Pada Proses Pembubutan Baja ST60. *Inovasi Teknologi Terapan*, 04(2), 367–375.
- Akbar, A., & Karmiadi, D. W. (2023). Vibration Analysis of the Influence of Misalignment Variables. *Journal Teknobiz* :, 11(3), 141–150.
- Alhaffis, F. (2020). Optimasi Parameter Pemesinan Terhadap Tingkat Kekasaran Baja St 40 Dengan Metode Taguchi. *INOVTEK*, 2(2), 65–71.
- Amin, Z., & Hajar, I. (2013). Gear Damage Detection Using

- Vibration Signal Analysis. *Journal Inovtek*, 1(1), 92–98.
- Ari Togar Maulana, M. F. (2026). Rancang Bangun Media Pembelajaran Simulasi Kerusakan Bearing Berbasis Analisis Getaran. *SNITT*, 2(1), 1–7.
- Bagasworo, F. A., & Machfuroh, T. (2026). Analysis of the Effect of Variations in Feed Rate and Cutting Depth on Lathe Machine Vibration according to ISO 1081. *Journal Metrotech*, 05(01), 44–55.
- Endriatno, N. (2022). Analisis Frekuensi Natural Dan Modus Getar Balok Kantilever Aluminium Dengan Metode Elemen Hingga Dan Eksperimental. *Journal Rekayasa Mesin*, 13(1), 231–238.
<https://doi.org/10.21776/ub.jrm.2022.013.01.22>
- Halim, A., Ilmawan, S., & Dedy, S. (2021). The Effect of Spindle Rotation and Depth of Cut of AISI 4140 Material for Bushing Manufacturing in Conventional Lathe Process. *Journal ROTASI*, 23(4), 8–17.
- Haris, D., Tumpu, M., Karawang, P., & Dumai, P. (2025). Analisis Getaran Kompresor Mesin Pendingin Pada Kapal Binama 07 Jakarta. 7(2), 226–237.
- Hutahaean, R. Y. (2022). Case Study Of Machine Failure Identification Based On Vibration Signals. *Journal Rekayasa Mesin*, 13(2), 305–318.
- Lesmana, D. D., Sakti, A. M., & Ibad, M. N. (2022). Vibration Testing on Centrifugal Pumps as a Preventive Measure to Maintain Pump Performance Stability. *Journal Rekayasa Mesin Unesa*, 11(01), 708–712.
- Mahdan, Z. E., & Yudo, E. (2025). Analisis Pengaruh Pahat Cnmg 120404 Pada Proses Bubut Cnc Terhadap Kekasaran Permukaan Baja S45c Dengan Metode Taguchi. (*TURBO*) *Jurnal Program Studi Teknik Mesin UM Metro*, 14(02), 709–716.
- Nur Asaf Abdullah. (2023). Analisis Pengaruh Kecepatan Putaran Mesin Bubut Dengan Menggunakan Pahat Hss Terhadap Kekasaran Permukaan. *Al- Gazali Journal Of Mechanical Engineering*, 2(29), 38–44.
- Nurul, S., & Suryanto, H. (2021). Pengaruh Kecepatan Putaran Spindel Terhadap Getaran Mesin Frais Pada Proses Pemakanan Dan Kekasaran Permukaan Benda Kerja. *JTM (Jurnal Teknik Mesin)*, 1(01), 13–18.
- Prakarsa Ade Putra Surbakti. (2021). Experimental Identification Of Vibration In The Transmission System Of A Sludge Separator Machine. *Journal Dinamis*, 9(1), 20–31.
- Putra, W. M., Martowibowo, S. Y., Tabah, G., Thamrin, L., & Yani, A. (2025). Taguchi-Based Optimization of Sheeting Machine Parameters for Improved Production Speed. *Journal Polimesin*, 23(1), 83–88.
- Sihombing, S., Nababan, W., & Sidabutar, R. A. (2021). Analysis of Vibration Characteristics on Apollo ANP-1500 Type Asphalt Mixing Plant

- Machine Based on Road Asphalt Making Capacity in Horizontal, Vertical and Longitudinal Areas Based on Time Domain. *Journal SJoME*, 3(1), 15–22.
- Simarmata, Firman Paniroi, Tomi Abdilah, S. (2026). Roller Bearing Damage Analysis on the Takuma Boiler Induced Draft Fan Blower at the XYZ Palm Oil Mill. *Jurnal Rekayasa Material, Manufaktur Dan Energi*, 9(1), 37–45.
- Suroso Bkti, P. D. (2019). Pengaruh Kecepatan Putaran Spindle Dan Kedalaman Penggerindaan Terhadap Kekasaran Permukaan Material Baja St 37 Menggunakan Mesin Bubut Bergerinda. *Jurnal Rekayasa Material, Manufaktur Dan Energi*, 2(1), 24–33.
- Susanto, T. A., & Kido. (2026). Pengaruh Kecepatan Putar dan Feed Rate Mesin Bubut pada Proses Lathe Cylindrical Grinding Terhadap Kekasaran Permukaan Aluminium. *TEMATIS*, 8(1), 15–24.
- Trihatmanto, R., & S, E. Y. (2024). Jurnal Mesin Material Manufaktur dan Energi Kelapa Model Adaptif. *Jurnal Mesin Material Manufaktur Dan Energi*, 4(2), 1–9.
- Widyanto, T., & Widodo, A. (2024). Perancangan Simulator Single Plane Balancing Untuk Mata Kuliah Praktikum Analisis Getaran Mesin. *SNTEM*, 4(November), 213–222.
- Yudistiro, D., Junus, S., Tunggal, D. H., Rahmawati, I., Amini, H. W., Rizkiana, F., Engineering, C., & Program, S. (2026). Integration of taguchi method and digital metrology for precision fused deposition modelling of PLA-based vibration-damping components. *Journal Polimesin*, 24(1), 55–63.
- Zaira, J. Y. (2025). Analisa Getaran Mesin Bubut 1214 terhadap Variasi Kecepatan Putaran Spindel Lathe. *Pendidikan Teknik Mesin Undiksha*, 13(1), 38–46.