Using the Sound Capabilities of Production Equipment for Self-Diagnostics

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Abstract. Can the technical equipment play music? Is it possible to diagnose their operation using melodies played on various machines? Is it even possible to describe music in the language of mathematics? After conducting experiments, answers to all questions were found. To achieve the goal of the scientific work – modelling and analytical description of the dependence of the pitch sound of the working equipment on the speed of its operation – a number of search and research tasks were set and implemented. These dependencies were then used to identify musical notes. Based on this, musical compositions were created using technological equipment. The ultimate purpose of this new approach was to enable equipment diagnostics based on sound analysis which it generates. The work proved the feasibility of using the graph-analytical method to search for a correspondence between the speed of operation of CNC equipment and the note it produces. The presented method found all possible notes produced by the researched CNC equipment in the operating speed range. Calculations were automated in Microsoft Excel software. We applied our note search method to various CNC technological equipment. During the performance of our research work, a malfunction of one of the CNC-machines was detected. This malfunction was successfully eliminated by using developed method. Thus, the possibility of sound diagnostics of technological equipment was confirmed.

Keywords: Sounds, Notes, Sound Dependence, Note Frequency, CNC Machines, Technological Equipment Diagnostics.

1 Introduction

Every day on the street, indoors, anywhere, we hear various sounds that can come from everywhere. In general, sounds can also be heard from various musical instruments, and it is possible to hear it from working equipment [1]. At the same time, the methods of obtaining sounds from machines can be different [2]. This state of affairs led to the study of a working technological machine, namely the sound signals of a CNC milling machine. After that to program a musical composition on it in order to diagnose the condition of its operation.

Such a diagnostic method is quite simple and at the same time should not require complex diagnostic equipment. Therefore, we consider the study of the above-described issue to be relevant. A simple check of the operation of technological equipment can help detect possible malfunctions. This, in turn, allows the equipment to continue operating effectively. The proposed method of acoustic diagnostics involves analyzing the sounds generated by a CNC machine during operation. A specially developed G-code is used to move the spindle along a specific axis (e.g., the Y-axis), causing the stepper motor to emit tonal signals at different speeds. These tonal signals correspond to musical notes, making it possible to generate recognizable melodies. Any mechanical or electronic deviation, such as backlash, motor skipping, or worn components, leads to audible distortions in the playback.

This approach represents a simple yet effective method of real-time condition monitoring within the framework of Industry 4.0 [3]. It enables the implementation of predictive maintenance strategies, reducing unplanned downtime and extending the equipment's useful life cycle. Acoustic signatures can be recorded, compared, and stored in digital form, forming part of the digital twin concept. By embedding sound-based diagnostics into the operation cycle of a CNC machine, manufacturers gain a low-cost and intuitive tool for assessing machine health without interrupting the process. Furthermore, the method can be automated and integrated into IoT-based monitoring systems, allowing remote diagnostics. Studies such as Wang [4] on acoustic pattern recognition for machine fault detection and Lee [5] on predictive maintenance in Industry 4.0 environments support the potential of sound-based approaches in modern manufacturing.

An example of such diagnostics of machine tools is given in the source [6]. This paper addresses the fault diagnosis knowledge discovery and the decision support model for fault diagnosis designed in a CNC grinding machine based on on-line vibration monitoring.

The purpose of our research is to conduct a theoretical and practical study the sound characteristics of the CNC milling machine in order to diagnose its operation.

Research objectives:

- practically and theoretically systematize sounds that the machine produces in different modes of its operation;
- develop a method for encoding a musical composition for a milling machine;
- conduct an approbation of the reproduction of a musical melody on a working CNC milling equipment in order to diagnose its operation.

The object of this study is the sound signals emitted by a working CNC milling machine. The subject of the study is the basics of acoustics and the operation of technological equipment and machines.

The practical significance lies in the experimental confirmation of the possibilities of diagnosing the operation of technological equipment based on the quality of the sound signals it emits. This work was performed in the Interfaculty Technology & Product Design Lab of Lutsk National Technical University.

2 Literature Review

Sound diagnostics of mechanized systems, for example, automobile internal combustion engines, is an effective way to preliminarily assess the correct operation of the system [7]. That is, the reference sound of a fully functional engine can be compared with the sound of the engine being diagnosed. It was analyzed important researches in this field, namely in acoustic diagnostics of the correctness of the operation of industrial equipment and machines, is presented in the works [8-15].

Accordingly, to some extent, something similar can be done with complex production technological equipment that works with the use of numerical control (CNC). Analyzing information [16] we can see how a milling machine with a CNC system was programmed to play a melody. Also, as another example, you can see that other mechanized systems that work under the control of electronics can be programmed to play musical compositions [17].

Accordingly, analyzing the above material, we can conclude that complex electromechanical systems are capable of performing the role of “musical instruments”. And by listening to the sound of musical instruments (in our case working technological equipment), we can evaluate their quality and condition (working well or not, damaged or not, well-tuned or not).

3 Research Methodology

From the very beginning, our task was to investigate sounds of a working CNC milling machine. Using musical hearing and the Solfa mobile app, we identified the sound notes that produces our experimental CNC milling machine (Fig. 1).

Fig. 1. Experimental CNC milling machine with 3-axis numerical control system

The Y axis was chosen as the machine unit that will produce sound. That is, to find a certain note, you need to set the machine a specific task. According to this task, the spindle unit should move a certain distance along the Y axis. This movement must occur at a specific speed.

The faster the machine covers the distance, the higher the note is played. For example, we set the movement speed to F390 (390 mm/min) and the machine produces the sound of the note C.

Next, we successfully found the sound notes that the CNC machine emit in different operating modes. The information obtained was presented in Table 1. In total, 25 basic notes in two octaves were found.

Table 1. Spindle speeds towards Y axis and corresponding sounds.

#	Feed rate, mm/min	Musical note
1	F390	C (Octave 1)
2	F415	C sharp / D flat (Octave 1)
3	F435	D (Octave 1)
4	F455	D sharp / E flat (Octave 1)
5	F490	E (Octave 1)
6	F515	F (Octave 1)
7	F540	F sharp / G flat (Octave 1)
8	F575	G (Octave 1)
9	F610	G sharp / A flat (Octave 1)
10	F655	A (Octave 1)
11	F690	A sharp / B flat (Octave 1)
12	F725	B (Octave 1)
13	F770	C (Octave 2)
14	F820	C sharp / D flat (Octave 2)
15	F860	D (Octave 2)
16	F910	D sharp / E flat (Octave 2)
17	F960	E (Octave 2)
18	F1025	F (Octave 2)
19	F1090	F sharp / G flat (Octave 2)
20	F1160	G (Octave 2)
21	F1200	G sharp / A flat (Octave 2)
22	F1305	A (Octave 2)
23	F1380	A sharp / B flat (Octave 2)
24	F1450	B (Octave 2)
25	F1590	C (Octave 3)

It is clear that the higher the speed of the machine, the higher the note sounds. We were interested to depict this graphically (Fig. 2). Along the Y axis, the speed of movement of the machine spindle along the Y axis is recorded, and on the X axis – the notes themselves.

This graph was built in the Microsoft Excel program in which you can set a mode in which you can see what dependence the constructed graph resembles. So, position 1 is a graph constructed based on experimental data, position 2 is the dependence that the Excel program searched. This dependence is part of an arc that has a coincidence coefficient of 0.9998 with the experimental curve, that is, almost identical.

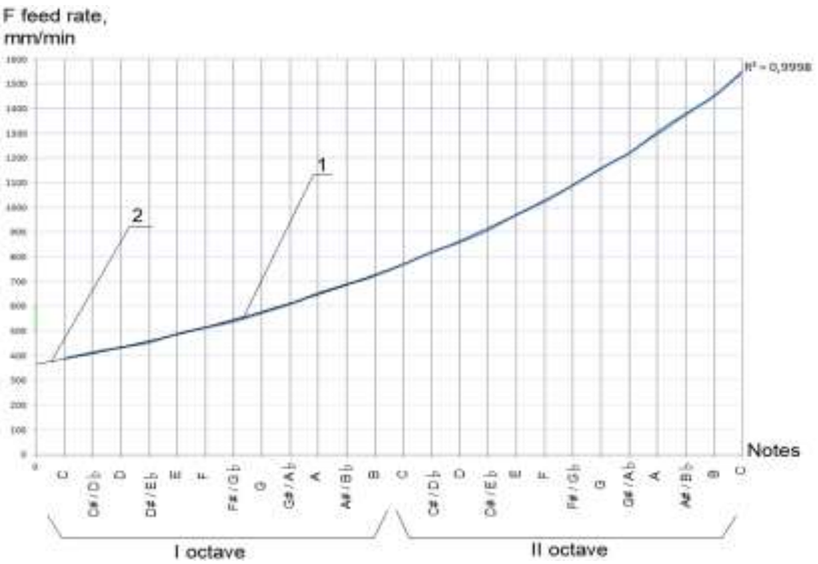


Fig. 2. Graph of dependence the CNC milling machine operation sound from the speed of its operation

Our next step was to simplify the programming of the machine in which it will produce sounds of a certain musical composition. We realized our intention in Excel software. In the program table, we created two areas. The first important area (Fig. 3) is the “programming language” that the musician understands (column A – musical note, column B – musical note duration).

So in the first area, in column A, notes themselves are being input. In column B, the durations of the notes are entered. Excel then selects the speed of the machine in column C. In column D, Excel calculates the distance the machine will travel. In other words, this distance represents the duration of movement. It is also worth paying attention to the pauses that may occur during the sounding process. It is also advisable to program a familiar melody (well known for everybody), the sound of which can be compared with the original.

Also important for ordering is the definition of the duration of notes: quarter, eighth, half, whole, sixteenth. And each of them sounds for a certain period of time. This time we determined experimentally depending on the musical composition.

The second area (see Fig. 4) is the “programming language” for the machine, which it will implement, thereby reproducing sounds of the musical composition. It is worth noting that the G-code language is used as the programming language for the CNC machine.

From Fig. 4, you can see that the Excel program is specially programmed. Its purpose is to convert the information from the first area into program code. This code determines how the machine will perform a movement. As a result, the machine emits a musical composition.

	A	B	C	D
1	Notes	Duration, sec	Feed rate mm/min	Distance, mm
2	A	0,6	655	2,274
3	Pause	0,1	0	0
4	A	0,6	655	2,274
5	C	0,6	390	1,32
6	A	0,6	655	2,274
7	D2	0,6	860	3,012
8	A	0,6	655	2,274
9	E2	0,6	970	3,408
10	D2	0,6	860	3,012
11	C2	0,6	770	2,688
12	Pause	0,1	0	0
13	C2	0,6	770	2,688
14	E2	0,6	970	3,408
15	C2	0,6	770	2,688
16	G2	0,6	1160	4,092
17	C2	0,6	770	2,688
18	E2	0,6	970	3,408
19	C2	0,6	770	2,688
20	G	0,6	575	1,986
21	Pause	0,1	0	0
22	G	0,6	575	1,986
23	B	0,6	725	2,526
24	G	0,6	575	1,986
25	C2	0,6	770	2,688
26	G	0,6	575	1,986
27	D2	0,6	860	3,012
28	C2	0,6	770	2,688

Fig. 3. Formation of a musical composition for CNC milling machine

	A	B	C	D
1	g91			
2		y 2,274		F 655
3		g04 x100		
4		y 2,274		F 655
5		y 1,32		F 390
6		y 2,274		F 655
7		y 3,012		F 860
8		y 2,274		F 655
9		y 3,408		F 970
10		y 3,012		F 860
11		y 2,688		F 770
12		g04 x100		
13		y 2,688		F 770
14		y 3,408		F 970
15		y 2,688		F 770
16		y 4,092		F 1160
17		y 2,688		F 770
18		y 3,408		F 970
19		y 2,688		F 770
20		y 1,986		F 575
21		g04 x100		
22		y 1,986		F 575
23		y 2,526		F 725
24		y 1,986		F 575
25		y 2,688		F 770
26		y 1,986		F 575
27		y 3,012		F 860
28		y 2,688		F 770
29		y 1,77		F 515
30		g04 x100		
31		y 1,77		F 515

Fig. 4. Formation the program code of a musical composition for CNC milling machine

Using the above-mentioned case as an example, the musical composition Mortal Kombat was prepared. A fragment of the notes is presented in Fig. 5. As a result of the work we did, we received a G-code, which, when launched, played a melody that can be listened by using the QR code link presented in Figure 6.

Fig. 5. Fragment of the Mortal Kombat musical composition [18]

Fig. 6. QR code on a video with the Mortal Kombat melody played by CNC milling machine

The spectrum of sounds produced by a machine tool during operation depends on the shape, size and material of parts, and the nature of their connections. Theoretically, it is extremely difficult to calculate it for different machine tool speeds. The graphical dependence of the musical pitch of the fundamental tone on the speed of movement of the machine spindle is part of a certain downward convex curve.

The exact analytical expression for this curve is unknown. However, within a small interval of operating speeds, the curve can be approximated. It can be simulated by one of the known curves – specifically, an arc of a circle. This approximation is done using certain parameters. We construct such a curve by three points (notes) and from the resulting graph we can find all other notes.

Let's show an algorithm for searching the sound of notes on technological equipment using the graph-analytical method.

Assume that we are looking for the sound of notes on an imaginary machine, the maximum working feed (feed rate) of which is equal to a certain F_{max}. The graphical part of the graph-analytical method involves several steps. First, it is necessary to identify any three notes by ear using the working equipment. Next, these notes should be plotted on a coordinate plane with axes "Number of tones (notes)" and "Machine feed speed". Then, using these three points, an arc should be constructed [19] (see Fig. 7).

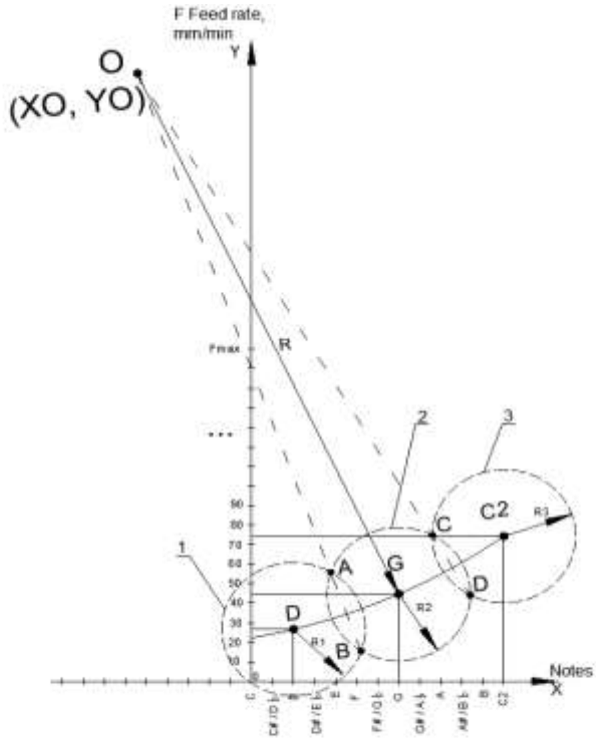


Fig. 7. Graphical part of the method for searching the notes on imaginary working machine by the graph-analytic method

At first, 3 musical notes were found, namely D (equipment operation at F = 27 mm/min), G (equipment operation at F = 45 mm/min) and C of the second octave (equipment operation at F = 75 mm/min). Let's construct circles (1, 2, 3), the centers of which are the notes found, but in such a way that they intersect and have the same radiuses ($R_1 = R_2 = R_3$). As we can see, the circles intersect at points A, B, C, D.

Let's continue the segments AB and CD in such a way that they intersect with each other. The point at which they intersect will be the center of the arc (O (XO, YO)), on which lie 3 points corresponding to the found notes. This is how you can find the radius of the circle and the location of the center of the circle, which is needed for the analytical part of the graph-analytical method.

The presented method is correct to use for searching notes in certain octave (a small interval of speeds). For neighboring octaves, the circle parameters will be different, since the arc of the circle is only an approximation of the real graphical dependence “note – machine feed rate”.

Analytical expression of the dependence of sound pitch on the feed speed of the machine is shown next.

Figure 8 shows all the data required for the analytical calculation of the machine feed rate at which a certain note is sounded on the technological equipment.

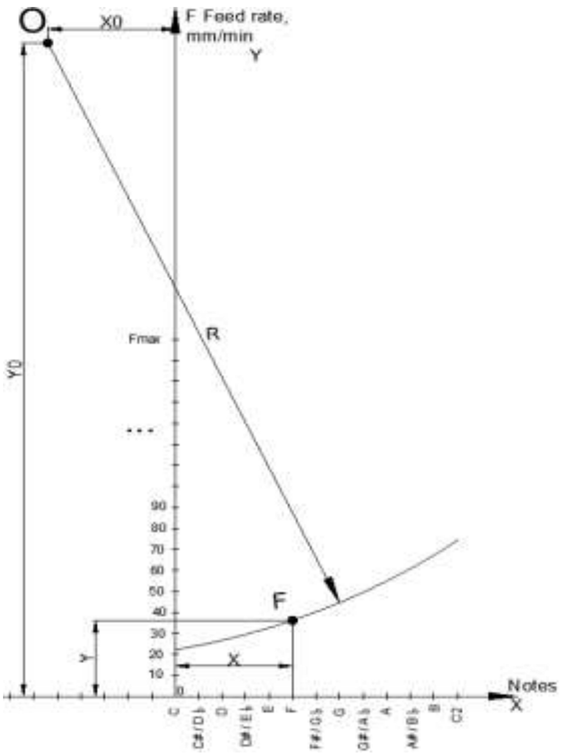


Fig. 8. Methodology of finding the note *F* analytically

For analytical representation of the dependence “feed rate – pitch” the circle equation was used [20]:

$$(X - X0)^2 + (Y - Y0)^2 = R^2 \tag{1}$$

here: $Y0$ – distance from the center of the circle (arc) to the Y axis (Fig. 8);
$X0$ – distance from the center of the circle (arc) to the X axis (Fig. 8);
R – radius of the circle (arc) (Fig. 8);
X – placement of the note on the X axis (the distance between adjacent notes along the X axis is fixed and the same, corresponds to the number of tones between them) (see Fig. 8).
Y – the desired value of the feed rate of the equipment (see Fig. 8).
Let's convert the equation of a circle into a form convenient for calculations.
Let's move the radius R^2 to the left side of the equation.

$$(X - X0)^2 + (Y - Y0)^2 - R^2 = 0\ . \tag{2}$$

Let's open the brackets containing the unknown value Y:

$$Y^2 - 2 \cdot Y \cdot Y0 + Y0^2 + (X - X0)^2 - R^2 = 0\ . \tag{3}$$

There is no need to open the brackets containing X and $X0$, since these quantities are known and are constant in this equation. For ease of presentation, we will name the constant part of the equation by the letter B:

$$Y0^2 + (X - X0)^2 - R^2 = B\ . \tag{4}$$

After substituting into equation B, we get:

$$Y^2 - 2 \cdot Y \cdot Y0 + B = 0\ . \tag{5}$$

We obtained a quadratic equation of the form:

$$ax^2 + bx + c = 0\ . \tag{6}$$

According to formula (5), in our case the values a, b and c will be as follows:

$$a = 1, \quad b = (-2) \cdot Y0, \quad c = B\ . \tag{7}$$

The solution of such an equation is carried out by calculating the discriminant D and finding the roots x_1 and x_2:

$$D = b^2 - 4 \cdot a \cdot c\ , \tag{8}$$

$$x_1 = \frac{-b + \sqrt{D}}{2a}\ , \tag{9}$$

$$x_2 = \frac{-b - \sqrt{D}}{2a}. \tag{10}$$

Thus, the coordinates of the center of the arc ($X0$, $Y0$) and its radius R can be found graphically. After that, the position of the desired note is specified on the horizontal axis representing the number of tones (X). Using this information, it becomes possible to analytically calculate the machine’s feed rates for all notes. These calculations apply to the selected speed interval and are performed using specific formulas (7-10).

4 Results and Discussion

To test the graph-analytical method described above, an experimental 3-axis CNC machine was chosen (which can act as a milling machine, laser engraver, 3D printer, or draftsman, depending on the functional element that will be attached to the moving head). This equipment is presented in Fig. 9.

For example, let's find the note F using the graph-analytical method. Experimentally, 3 notes were found by musical hearing: G, A, B. From the three points presented, we constructed an arc and found the radius of the circle and the location of its center (see Fig. 10).

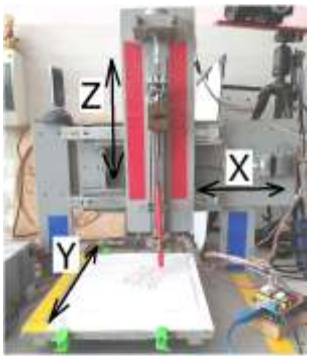


Fig. 9. Experimental 3-axis CNC machine

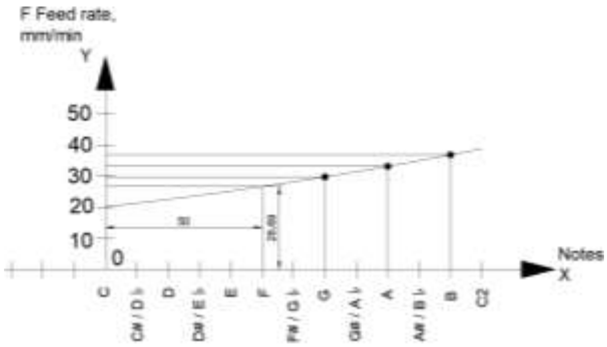


Fig. 10. Constructing the arc for dependence of sound pitch (note) (for octave 1) from feed rate of experimental 3-axis machine tool

To perform the calculation, the necessary numerical data are given below:

$Y0$ = 1428.2 – distance of the center of the circle (arc) to the Y axis (not shown in the figure);

$X0$ = –157.44 – distance of the center of the circle (arc) to the X axis (not shown in the figure);

R = 1416.77 – radius of the circle (arc) (shown in Fig. 10);

X = 50 – placement of the note on the X axis (shown in Fig. 10).

At first, using formula (4), we can find B:

$$B = Y0^2 + (X - X0)^2 - R^2 = 1428.2^2 + (50 + 157.44)^2 - 1416.77^2 =$$
$$= 2039755.25 + 43031.35 - 2007237.23 = 75549.36.$$

Next, we can find *a*, *b*, *c* using formula (7):

$$a = 1;$$
$$b = (-2) \cdot 1428.2 = -2856.4;$$
$$c = B = 75549.36.$$

Find the discriminant *D* using formula (8):

$$D = b^2 - 4 \cdot a \cdot c = (-2856.4)^2 - 4 \cdot 1 \cdot 75549.36 =$$
$$= 8159020.96 - 302197.44 = 7856823.52.$$

According to (9) and (10), we can find the roots x_1 and x_2:

$$x_1 = \frac{-b + \sqrt{D}}{2a} = \frac{-(-2856.4) + \sqrt{7856823.52}}{2 \cdot 1} = \frac{2856.4 + 2803}{2 \cdot 1} = 2829.7;$$
$$x_2 = \frac{-b - \sqrt{D}}{2a} = \frac{-(-2856.4) - \sqrt{7856823.52}}{2 \cdot 1} = \frac{2856.4 - 2803}{2 \cdot 1} = 26.7.$$

We obtained 2 roots, which are the feed rates *F*. Since the experimental CNC machine has a limitation on its operating speed (F_{max} = 110 mm/min – determined experimentally), the feed rate value for the note F will be only 26,7 mm/min, since it is must be less than F_{max}.

It should be noted that the above calculations do not follow the rules of approximation regarding the number of significant figures. However, since, as will be shown below, all calculations are automated, we have decided not to manually round intermediate results.

Fig. 11 shows the curve of dependence the pitch from the feed rate for the experimental machine. The curve consists of three parts, each showing the position of the notes of one octave (the third is incomplete due to the limitation of the maximum feed rate of the machine). Each part of the curve is an arc of a different radius with a different position of the center of the circle. The notes along which the arcs were constructed, as well as the octave boundaries, are marked with vertical lines.

From Fig. 11 we can see that to find the radius of the circle for the 1st octave, 3 notes were found experimentally by musical hearing: G, A, B (*R* = 1416.17). For the 2nd octave, 4 notes were found: C2, E2, G2, B2 (*R* = 637.39). For the 3rd octave, 3 notes were found: C3, D3, F3 (*R* = 600.52). As we can see, the higher the octave, the smaller the radius of the circle. According to the experimental data obtained from the constructed arc, it is possible to determine all other notes. In other words, the feed velocities at which these notes sound can be identified. This is done using the graph-analytical method described above. To simplify the calculations for finding the necessary notes, formulas were written in Excel, using which the analytical part of the graph-analytical method was automatically calculated.

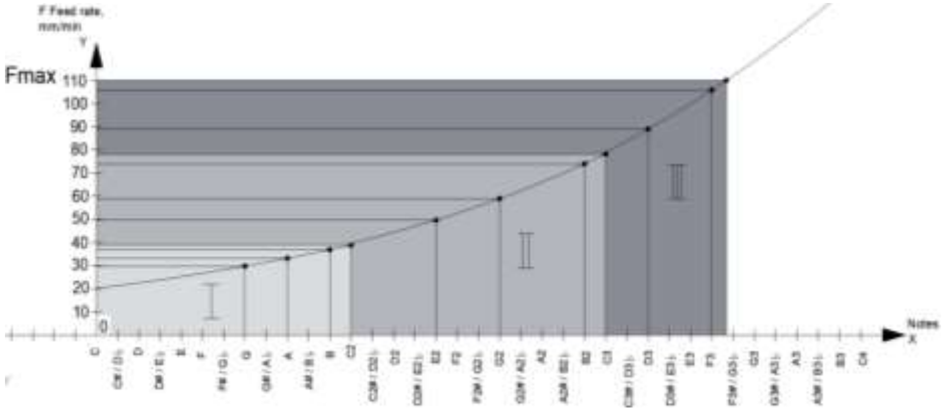
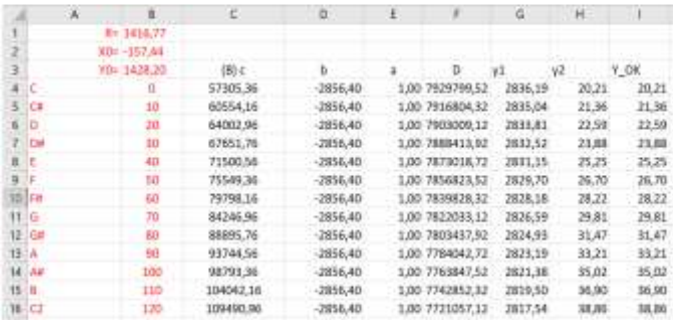


Fig. 11. Arcs of dependence the notes that sounds (2nd complete and 3rd incomplete octave) from the feed rate of our experimental 3-axis machine tool

Figure 12 shows an automated version of the analytical part of the graph-analytical method. For example, in column B (1, 2, 3) we input numerical data (radius of the arc, distance of the center of the arc from the origin), which are included in formulas for calculation. In column A (4-16) we need to input names of notes that we want to find. In column B (4-16) we need to input the X coordinate of notes themselves (we take the distance between adjacent notes to be 10).



	A	B	C	D	E	F	G	H	I
1		R= 1416,77							
2		X0= -157,44							
3		Y0= 1428,20	(B) c	b	a	D	y1	y2	Y_OK
4	C	0	57305,36	-2856,40	1,00	7929799,52	2836,19	20,21	20,21
5	C#	10	60554,16	-2856,40	1,00	7916804,32	2835,04	21,36	21,36
6	D	20	64002,96	-2856,40	1,00	7903009,12	2833,81	22,59	22,59
7	D#	30	67651,76	-2856,40	1,00	7888413,92	2832,52	23,88	23,88
8	E	40	71500,56	-2856,40	1,00	7873018,72	2831,15	25,25	25,25
9	F	50	75549,36	-2856,40	1,00	7856823,52	2829,70	26,70	26,70
10	F#	60	79798,16	-2856,40	1,00	7839828,32	2828,18	28,22	28,22
11	G	70	84246,96	-2856,40	1,00	7822033,12	2826,59	29,81	29,81
12	G#	80	88895,76	-2856,40	1,00	7803437,92	2824,93	31,47	31,47
13	A	90	93744,56	-2856,40	1,00	7784042,72	2823,19	33,21	33,21
14	A#	100	98793,36	-2856,40	1,00	7763847,52	2821,38	35,02	35,02
15	B	110	104042,16	-2856,40	1,00	7742852,32	2819,50	36,90	36,90
16	C3	120	109490,96	-2856,40	1,00	7721057,12	2817,54	38,86	38,86

Fig. 12. Automation of calculations of the analytical part in the graph-analytical method

Fig. 13. QR code of C major gamma

In column C (4-16) the variable c is automatically calculated (see formula (4)). In column D (4-16) – the number b (see formula 7), and in column E (4-16) – a (see formula 7). In column F (4-16), the discriminant D (see formula 8) is automatically calculated, and in columns G (4-16) and H (4-16), the roots (see formulas 9 and 10) of the equation are calculated. In column I (4-16), the values which are not exceeding the value F_{max} are recorded.

The given example of automated calculation is valid only for the 1st octave. In the 2nd and 3rd octaves, the values contained in columns A and B differ from those in the example. However, these values can be calculated in a similar way.

Using the melody composition method introduced previously, we generated a G-code that enabled an experimental 3-axis machine tool to play the C major gamma [21]. You can listen to this melody using the QR code shown in Fig. 13.

The ideas of diagnosing machines using acoustic analysis has been studied by various researchers [22, 23], but they have not yet been widely used. While listening to the first experimental musical composition Mortal Kombat, a problematic operation of the machine was discovered (you can listen to this composition using the QR code given in Fig. 14, titled Mortal Kombat (problematic sound). After inspecting the cnc-machine, we discovered the source of the problem. The plastic coupling that connects the stepper motor to the Y-axis lead screw was worn out (see Fig. 15). As a result, there was backlash during operation. This backlash caused the machine to produce noise. After carrying out certain repair work to eliminate the backlash in the coupling (see Fig. 16), the issue was resolved. You can now listen to the same version of the musical composition again. This composition is available via the QR code shown in Fig. 17, titled Mortal Kombat (good sound). The new playback has a noticeably better sound quality. This improvement indicates that the problem in the machine has been successfully eliminated.

Fig. 14. Mortal Kombat (problematic sound)

Fig. 15. Worn coupling connecting the stepper motor to the Y-axis lead screw

Fig. 16. Adjusted coupling connecting the stepper motor to the Y-axis lead screw

Fig. 17. Mortal Kombat (good sound)

This example demonstrated the viability of the idea of diagnosing the CNC milling machines operation using musical compositions.

5 Conclusions

The paper presents a description of the systematization of sounds emitted by CNC milling machines. These sounds were used to create musical compositions working technological equipment. It is worth noting that the creation of the program code by which all machines played melodies was carried out in an automated mode using Microsoft Excel software. The paper provides an example of self-diagnosing the operation of an experimental CNC machine using a test melody for identifying malfunctions and successfully it's eliminating. This approach has been proposed for the first time. During the implementation of our project, we systematized the sounds produced by machine tools in different operating modes. The methodology has been further developed and this systematization was carried out both practically and theoretically. We also developed a method for encoding a musical composition specifically for CNC milling machines. In addition, we tested the playback of musical melodies on operating CNC milling equipment. This was done with the goal of diagnosing the machine's operational condition.

The paper describes our proposed graph-analytical method for searching for notes in the sound of technical equipment when it operates at different feed rates. The found notes are used to play musical compositions on machines for the purpose of sound diagnostics of this technological equipment. We have proven that the dependence of the pitch on the feed rate of the machine can be considered as an arc of a circle within one octave. A method of constructing an arc based on three experimental points is described. From the resulting graph, all notes of the corresponding octave can be found. An analytical expression of the graphical dependence is given and formulas are derived for calculating the feed rates at which the desired notes sounds. To simplify the calculation process, the note search method was automated. Using this method, the sounding of notes for 3-axis experimental CNC machine in different modes of its operation was found. At first time developed and tested graph-analytical method of searching the notes for sound diagnostics of technological equipment has shown its effectiveness and can be applied for various types of CNC machines. In future work we will adapt our approach and solutions to diagnostic another types of CNC-machines according to requirements of machine-building Industry.

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