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# Investigation of the sound intensity level in the case of a universal lathe

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**Abstract.** The phonic pollution is a problem of interest in the mechanical workshops. Various solutions could be applied in order to diminish the intensity level of the sound generated by various noise sources. The research presented in this paper aimed to highlight some aspects concerning the measuring of the sound intensity level in a mechanical workshop and some possibilities of decreasing the sound intensity level by using fences made of distinct materials. The sound intensity level corresponding to the use of a universal lathe was experimentally measured by means of an adequate apparatus. The results of experimental research were mathematically processed and some empirical mathematical models were determined. The analysis of the experimental results and empirical mathematical models highlighted the influence exerted by some factors on the sound intensity level and some possibilities of diminishing the phonic pollution by using various phonic fences.

## 1 Introduction

According to the literature, the phonic pollution represents the process of surrounding medium contamination with materials that interfere with human health, the quality of life or the natural function of ecosystems (live organisms and their habitats). Even though sometimes the pollution of the surrounding medium results from natural causes like volcanic eruptions, the most of polluting substances comes from human related activities.

*Acoustic pollution,* also known as *phonic pollution* or *sonic pollution,* represents a significant component of the pollution process of our surroundings by its harmful nature. By its presence in all modern life compartments, the sonic pollution represents a major issue for all highly economically developed countries and for the emergent ones [1-5].

Phonic pollution materializes by a continuous aggression determined by distinct sound that are produced by cars, equipment, industrial or domestic machines, inside or outside constructions, buildings, chambers, etc. The intensity of noise may be influenced by the way by which noise sources are put into place and how they should be contained.

Studies about acoustic pollution regarding the determination of any type of sound, especially for the industrial environment protection etc. related domains use sonic meters

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(equipment that measures the acoustic pressure level).

By the help of such an equipment and by repeated measurements, we may obtain a so called noise map, which may be available for a certain area or surface.

Fighting against noise represents a problem for each work place that may be considered as a real system. In this case, by *system* we refer to the assembly that was formed by the noise source, the environment (the path on which the acoustic energy is propelled) and the receiver. The source is that part of the system where acoustic energy is generated. In general, the source should be considered as a group of noise generators that may have distinct physical characteristics and with a certain distribution in time and space.

Fighting noise does not mean only reducing its intensity level, as temperature adjustment does not always mean that it will decrease. But we all can agree upon the fact that a lot of noise fighting related issues are solved by reducing the acoustic power or acoustic pressure with a certain degree of confidence. There are situations in which the recommended solution focuses, for example, on modifying only the noise frequency spectrum.

In paper [1], the authors show that diagrams of stability must be developed in combination with the development of a FEA analysis, in order to be able to determine the dynamic performance of machines. The authors present two different ways to obtain such diagrams. They have conducted experimental test on a horizontal lathe. The results they have recorded are similar to those obtained by numerical simulation in the time frame of the proposed analysis.

In another paper [2], the authors base themselves on conducting experimental studies also on results obtained from the simulation and by doing this, they hope to achieve a better stiffness for the tools they use in order withstand the intense vibrations generated by the machining processes. They have succeeded to obtain an improvement in terms of machined surface quality. According to other researches, the authors have highlighted vibration phenomena that appear between the tool and the tool holder; such vibrations influence in a negative way the roughness state of the machined surfaces [3].

The present study aims to highlight the way in which several noise producing factors interact and behave during cutting processes performed on a universal machine tool as part as machine manufacturing processes. The paper also highlights the need for new and improved techniques and technologies to reduce phonic pollution. Such solutions may require additional investments, new materials from civil and industrial engineering as part of the machine manufacturing industry, but also they may require rethinking new procedures as well as machining processes.

## 2 Theoretical considerations about sonic vibrations generation in case of a lathe machining

The main sources of vibration in the case of developing a turning process on a lathe are the electric engine, the gearing between the engine and the gearbox, the existence of some worn parts inside the gearbox and even the cutting process itself.

Figure 1 shows a upper view of a lathe, highlighting the most significant noise sources and how the noise intensity level measurement process takes place, but also the how fences may be put into place in order to diminish the intensity of the noise propagation process in the neighborhood of the machine tool equipment.

Vibration appearance is inevitable during lathe functioning. Its presence is more than often harmful to the lathe functionality and machining process. It is considered that inside the lathe's internal structure may appear free vibrations, forced vibrations and auto vibrations (self-maintained), thus the vibrating phenomenon being frequently accompanied by noises with distinct patterns.

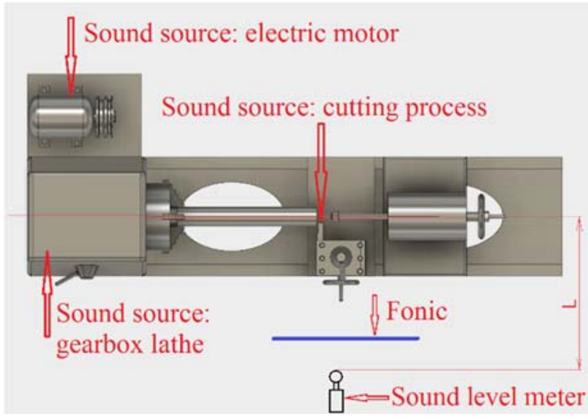

**Fig. 1.** Sound sources and measuring the sound level intensity in the case of a universal lathe.

Free vibrations have a relative short time when they do manifest, being amortized by different joints between lathe sub-assemblies. The kinematic and dynamic factors that correspond to a proper functioning of the lathe generate forced vibrations that display a continuous presence during the machine tool functioning.

Forced vibrations that appear during functioning may be classified taking into consideration all excitement sources: a) forced vibrations which do not depend on the cutting process; b) forced vibrations which depend on the cutting process.

Vibrations that do not depend only on the cutting process may be highlighted experimentally during machine tool idle state. They can be generated also by other equipment found in the neighborhood or other functioning machine tools and may appear due to inertia forces that intervene as result of the revolution movements of machine parts or unbalanced subassemblies. These vibrations may amplify sometimes due to an inappropriate fixation of equipment onto foundation or because of technological imperfections in terms of machining and assembling the parts of machine tool. The main sources of vibrations and noises in the case of machine tools are their mechanical transmissions, which are composed out of gears, bearing housing, electrical motors, but also the cutting process itself. The noise produced by bearings may appear due to direct and indirect propagation of vibration that appear as a result of the relative movement of components (rolling holders, rings, cage) during functioning conditions. Based on the analyses of bearing vibration causes, few general recommendations were formulated regarding the decrease of noise, such as: using silent bearings with a higher accuracy level, diminishment of impurities from contact surfaces, elimination or reduction of clearances when the axial bearing is being used (by axial preloading).

Globally studies show that the most important noise and vibration sources inside machines and mechanical equipment are the gears. One of the main reason is considered to be the ever increasing need for high power and speed of modern equipment, as they become lighter and smaller. These imposed conditions to worsen the acoustic vibrating behavior of gears and gearing, because even from the drawing board, but also during execution and fitting, no compliances were made towards optimization criteria of equipment's acoustic behavior. Reducing noise and vibrations produced by gearing becomes one of the main elements in fighting sonic pollution.

As a result of analyzing the statistical information by regulations, one notice that there have been imposed some admissible threshold noise levels, established for each domain: medical, technical, economical and professional. For the technical domain which includes machine tools, the admissible values for noise levels have been presented in the older standard STAS 8857-87 and they can reach up to 80-81 dB, depending on the machine tool that is used.

Vibrations are transmitted through environment as the machine tool is surrounded by a complex acoustic field. This acoustic filed is characterized by the energy of vibrating sources and by the acoustic properties of the chamber in which the machine tool performs.

**Fig. 2.** Soundmeter type Voltcraft model DT 8820.

The main factors that may influence the intensity level of vibrations during cutting processes are the cutting parameters, the length of the workpiece zone which is not additionally supported or fixed, the tool's length found cantilever, the tool's active wear state, the type of metallic carbide tool tip and the way in which it gets assembled in the tool holder.

## 3 Experimental research

The objective of the experimental research was to measure the intensity of the vibration phenomenon corresponding to the lathe functioning, both during the machining process and idle operation. In accordance with the accepted definition, the $L_i$ sound intensity level or acoustic intensity level (a logarithmic quantity, expressed in dB) is the level of the intensity of a sound relative to a reference value $I_0$

$$L_i = 10 \cdot \log_{10}\left(\frac{I}{I_0}\right) \tag{1}$$

As a reference sound intensity level in air, the value $I_0$=1 pW/m$^2$ is used. The measurements were made on a universal lathe type SN 400x1000, for which the workpiece maximum diameter turned over the lathe bad is of 400 mm and the distance between centers is of 1000 mm. The main shaft rotation is obtained by means of an electric motor able to offer a power of 15 kW at a speed rotation of 1480 rev/min.

In order to measure the intensity of vibrations, a multifunctional apparatus type Voltcraft model DT 8820 was used (Figure 2). The apparatus allows determining of some microclimate parameters, having also functions of luxmeter, hydrometer and thermometer.

To materialize a turning process, a turning carbide-tipped tool was used. The hard material of the tool active part was the metallic carbide P30. As a test piece, a cylindrical laminated bar made of a steel alloyed with molybdenum and chromium was used. All the measurements were made in front of the lathe, at a height of 1 m relative to the flooring. In some cases, fences made of distinct materials were placed in front of the sound level meter, in order to see the effect of sound damping. Some of the experimental results obtained by means of the sound level meter were included in Tables 1, 2 and 3.

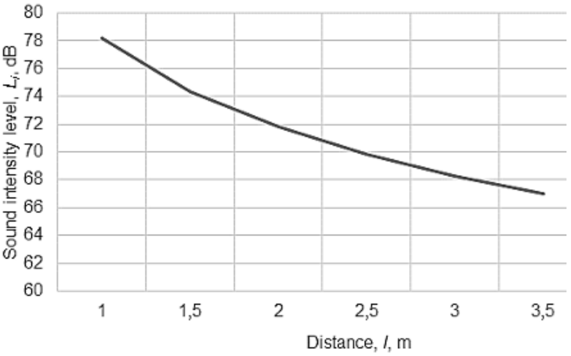


**Fig. 3.** Influence exerted by the distance $l$ on the sound intensity level $L_i$ during the idle operation (in accordance with the relation (2)).

The experimental results were

mathematically processed by means of a specialized software based on the least square method [4]; power functions were preferred in order to model the studied phenomena, due to the possibility to easier highlighting the effects exerted by some independent variables on the intensity of sounds generated by the lathe found in distinct situations. The adequacy of the power type empirical models to the experimental results was evaluated by means of the Gauss's criterion.

Thus, in the Table 1, the results obtained during the electric motor rotation were inscribed; one must mention that the lathe main shaft was not trained in rotation movement.

**Table 1.** Intensity of the sound generated by the electric motor during the idle operation (the lathe main shaft was not trained in rotation movement)

| **Sound intensity $L_i$ (idle operation, only the rotation of the electric motor)** | **Measuring distance, *l*, m** | | |
|---|---|---|---|
| | **1** | **2** | **3** |
| Measured values, dB | 78 | 72.2 | 68.5 |

The empirical mathematical model corresponding to the measured values included in table 1 is the following:

$$L_i = 78.174 \cdot l^{-0.123} \quad (2)$$

for which the Gauss criterion has the value $S_G$=9.616448*10$^{-2}$. For the experimental results include in Table 2, the following empirical model was determined:

$$L_i = 62.180 \cdot n^{0.040} \cdot l^{-0.0249}, \quad (3)$$

the Gauss criterion having the value $S_G$=2.670875.

**Table 2.** Sound level intensity when the lathe main shaft is trained in rotation movement with distinct rotation speeds

| **Rotation speed, *n*, rev/min** | **Intensity of sound level intensity, $L_i$, in dB, relative to distance to the universal lathe, *l*, m** | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| 380 | 80.1 | 79.2 | 77.7 |
| 765 | 79.8 | 77.8 | 76.8 |
| 1500 | 84.1 | 83.8 | 82.8 |

In the case of this dependence $L_i=f(n, l)$, the software showed that a more adequate empirical model is that based on a polynomial of second degree:

$$L_i = 84.422 - 0.0121 \cdot n + 0.0000086 \cdot n^2 - 0.915 \cdot l - 0.05 \cdot l^2, \quad (4)$$

for which the Gauss criterion has the value $S_G$=0.1308351.

Considering that there is a possible correlation between the sound intensity level $L_i$ and the roughness of the machined surface, the values of the *Ra* surface roughness parameter were measured; one noticed that relatively high values were obtained on the machined surfaces (*Ra*=7.02-8.87 µm).

Some experiments aimed to highlight the influence exerted by the distance *l* between the soundmeter and lathe and the depth of cut $a_p$ on the sound level intensity $L_i$, this meaning just during the process of machining of the test piece made of alloyed steel. The experimental results obtained in this case are presented in table 3.

The power type empirical mathematical model corresponding to the information included in table 3 is the following:

$$L_i = 81.62 l^{-0.0472} a_p^{\ 0.00855}, \quad (5)$$

the Gauss's criterion having the value $S_G$=0.1206107.

**Table 3.** Sound intensity level in case of turning and when using various materials as fences, respectively

| Distance $l$, m | Depth of cut $a_p$, mm | | | | Cardboard | Paper A4 | Cellophane | Plywood | Synthetic material |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 5 | 10 | 300x190 | simple | 1000x500 | | |
| 1 | 81.7 | 82.1 | 82.7 | 83.5 | 81 | 80.2 | 71.2 | 74.2 | 78.8 |
| 2 | 78.9 | 79.1 | 79.3 | 81.1 | 79.1 | 78.4 | 68.1 | 69.1 | 77.5 |
| 3 | 77.9 | 78.1 | 78.6 | 78.9 | 77.9 | 76.9 | 67.7 | 70 | 76.3 |

On the base of the empirical mathematical models, the graphical representations from Figures 3 and 4 were elaborated. The analysis of the empirical mathematical models and of the graphical representations allowed establishing of some general remarks. Thus, one noticed that, as expected, the increase of the distance $l$ between the sound source and the soundmeter determines a diminishing of the $L_i$ sound intensity level. At the same time, the increase of the rotation speed $n$ has as a result an increase of the $L_i$ intensity sound level.

## 4 Conclusions

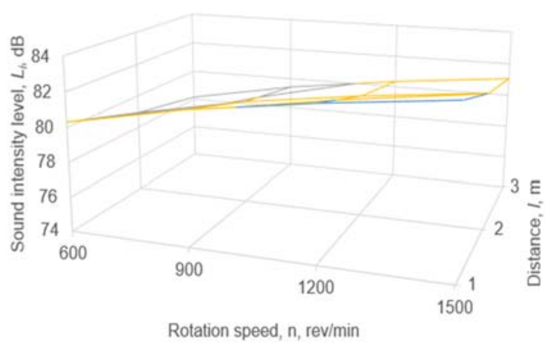


**Fig. 4.** Influence exerted by the speed rotation $n$ and distance $l$ on the $L_i$ sound intensity level when the lathe main shaft is trained in rotation movement

The vibration generated during the functioning of the lathe, both in idle operation and during the machining process, could be considered as a phonic pollution source. The analysis of the turning process developed on a lathe highlighted the main sources of vibrations. An experimental research was planned and materialized, in order to evaluate the influence exerted by some turning process input factors and also by some materials of fences placed in order to diminish the sound intensity level. By processing the experimental results, empirical mathematical models were determined. On noticed the diminishing of the sound intensity level when the rotation speed of the lathe main shaft reduces and when the distance from the machine tool is higher. Some fences materials proved a good capacity of dumping the sound intensity.

## References

1. G. Urbikain, F.-J. Campa, Journal of Sound and Vibration **340**, 317-330, (2015)
2. V. Khoroshailo, V. Kovolav, Procedia Technology **22**, 153-160, (2016)
3. M. Thomas, Y. Beauchamp, Computers & Industrial Engineering **31**, 3-4, 637-644, (1996)
4. G. Crețu, *Fundamentals of experimental research. Laboratory handbook* (Technical University of Iași, Romania, 1992)