ACUTE ASPECTS OF THE USE OF CONCENTRATE DIFFERENCES

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ABSTRACT*:* The paper presents the main active and passive applications of ultrasounds. There is a general form of an applicative installation that uses ultrasounds. A comparative study is performed between the concentrators in terms of amplification factor and material.
KEYWORDS: ultrasound, concentrators, amplification factor

1. INTRODUCTION

The processing or use of ultrasonic energy has found very diverse applications in different branches of the art and in other fields, due in particular to the properties of ultrasounds [1, 2]:

- low wavelength;
- very high particle acceleration (10^5g);
- ability to direct ultrasonic energy in hard-to-reach places;
- the ability to concentrate and focus energy in a limited space.

The applications where the ultrasonic energy used is large enough to produce structural changes in the environment in which propagation and dimensional changes are propagated are called *passive active* or technological applications. The main domains are: medicine, pharmacy, biology, chemistry, metallurgy, machine building industry (various fields). [1, 2]

Applications where ultrasound has a relatively low intensity and cannot cause structural and dimensional changes, only fulfilling the role of collecting information on the object being examined is called *passive applications*. The main areas are medicine, biology, metalworking, telecommunication, geology. [1]

2. APPLIED INSTALLATION WITH ULTRASONIC

The emergence and development of the ultrasonic dimensional processing method is based on the fact that it allows the processing of new materials with special properties such as: diamonds, metallic carbides, sapphires, mineral-ceramic materials, polycrystalline materials, bottles, under the conditions of superior technical and economic indicators, stainless steel, refractory, magnetic materials, materials from which can be manufactured pieces of various sizes and configurations. Dimensional processing by ultrasonic abrasive erosion is irreplaceable in a number of operations such as:

- rectifying the wire ropes;
- making boreholes in fragile mineral-ceramic parts;
- rectifying boreholes in pieces made from "new materials" by sintering.

The realization of an ultrasonic installation is determined by the field of use, and in the case of processing the application of specific processing technologies. The variants adopted must reduce the loss of acoustic energy in each element of the system by providing for an appropriate impedance of adjustment between the components as well as working locations and acoustic links that resist the static and dynamic loads imposed by the operating conditions. In Figure 1 is shown in schematic form an installation used for dimensional processing in the ultrasonic field [1, 2, 3].

Such a facility consists of the following main parts:

1. The ultrasound generator converts the industrial frequency electric current into high-frequency current for the purpose of supplying the electro-acoustic transducer. Universal generators can be connected to a wide variety of transducers, depending on the requirements of the use of ultrasound, allowing a wide variety of output parameters: power; frequency; voltage; impedance and amplitude. In case of specialized generators, the output parameters are invariant, working only at fixed frequency and constant output power. The efficiency of the generator depends on the type of frequency conversion device and the quality of the subassemblies and the parts used in their construction.

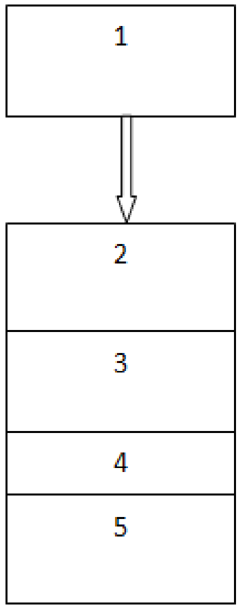

Figure1.Scheme of the ultrasonic processing plant.

2. The transducer converts the electrical energy received from the generator into a radiant mechanical energy with some efficiency. The physical principle of the transducers is divided into two main categories: magnetostrictive and piezostrictive. There are a wide variety of transducers, made in a wide range of resonant powers and frequencies, adopted for operation in relation to electronic generators, and at the same time adopted as shape, size, cooling conditions, corrosion resistance, existing conditions of use in the installation in which they are incorporated.

3. Mechanical fastening elements with acoustic insulation make an efficient connection between the acoustic system and the strength structure of the respective technological application, while pursuing an efficient acoustic insulation between the two parts. These elements allow the transmission of acoustic energy to the working surface, stopping it from transmitting to the plant.

4. The mechanical-acoustic couplings make both the mechanical and acoustic connections between the surfaces of the two contacting elements: the concentrator transducer and the tool concentrator. These elements must transmit without loss the acoustic energy is the useful amplitude $\mathbf{A_u}$. For energetic reasons (elimination of losses) and dynamic stability, the mechanical-acoustic system must be mounted in an oscillating node. In some situations, mechanical fasteners (acoustic couplings) and mechanical couplings are together.

5. The concentrator transmits acoustic energy from the transducer to the tool generating an amplification of the wave amplitude and is made of a material that best resists wear and tear. Particular attention must be paid to the geometry of this element. The concentrator supplies the Au useful amplitude, with minimal energy losses and high resistance to wear and tear. Each element is dimensioned on the principle of resonance frequency, in which case its length must be an integer of half the wavelength.

$$L = n \lambda / 2; \quad (1)$$

Where n - integer number:

λ - Wavelength.Particular attention is paid to the geometry of this element.

3. TRANSMISSION OF ULTRASONIC WAVES

In the case of a field less application, the ultrasonic generator and the transducer are considered fixed elements with well-defined characteristics, so no changes are made to them.

Mechanical fasteners are elements that can influence the smooth running and operation of the machine. We choose the best solutions, which cannot be changed for a given installation. In order to achieve the stabilization of the acoustic system during operation, a decisive role is the fixing (stiffening) of the system in the structure resistance of the installation. The requirement is that the fixation of the acoustic system is done at the nodal points.

Mecano-acoustico couplings are those that perform wave's attenuation, reducing the amplitude of input to the acoustic amplifier (concentrator). This depends on the efficiency of the installation.

It is found that in this area the US passes through three mediums, solid - gaseous - solid. It is intended to achieve only the passage through two solid-solid environments. In order to achieve this, certain conditions are set: perpendicularity between the axis of the concentrator and the contact surfaces, the symmetry axes to correspond, as well as a lesser roughness of the contact surfaces. They must be cleaner, cleaner, cleaner.

For dismountable joints, a watertight contact between the system elements must be achieved, as there is a significant loss of acoustic energy or even the destruction of the joint (when the gas appears between the surfaces). When connecting a circular cross-section concentrator with a rectangular section transducer, the concentrator's surface must be that of the transducer.

The acoustic concentrator is the amplifier of the acoustic pressure, giving the consistency of the ultrasonic phenomenon. It is the one that can change according to the purpose of the application. In various applications, different types of concentrators are used: conical, exponential, cathenoidal or cylindrical in stages.

The material from which the concentrator is made can influence amplitude amplification.

4. EXPERIMENTAL CONSIDERATIONS

The concentrator is that component of the installation that concentrates the acoustic energy in the workspace, that is, amplifies the acoustic power of the waveform, maintaining the relatively constant frequency. Their principle consists in concentrating, focusing ultrasounds by getting a parallel beam from where they have a higher acoustic power.[4]

Optical or sonic (acoustic) waves also rely on some phenomena such as reflection, refraction, attenuation, diffraction, composition (summation).

Two constructive cases of concentrators are studied: section jump concentrators and variable section concentrators.

4.1 Cross-section concentrators

The acoustic power of a sound source is the amount of acoustic energy emitted by the source or transported by a beacon in the time unit in the direction of the propagation of the wave. The total power transported over a surface by a sound wave is equal to the product of the wave intensity on that surface and the surface area, if the intensity is uniform on the surface

$$P = I\,S = p\,v\,S \qquad (2)$$

Where: I - Acoustic intensity [W / m2];

S - Contact surface [m2];

v - Propagation velocity in the environment (c) [m / s];

p - Acoustic pressure [N / m2].

The Acoustic pressure it is a variable size, its value being between two peak sizes **pv** resulting from stretching and compression stress. The value of the effective pressure is given by the rally:

$$p = 0.707\,pv \qquad (3)$$

In order to obtain this value, besides the weight of the ultrasonic block itself, it acts with a certain pneumatic pressure. The pressure is experimentally determined because too small a value reduces the impact effect and too much breaks the abrasive particles, reducing the processing effect.

It is considered a plane wave of constant frequency and with some amplitude and at the entrance in section S11 it will have the acoustic power, incidence (Pi= P1). At the exit of the jump area, section S2 will output power, transmitted power (Pt=P3) and reflected power (Pr=P2), shown in Figure 2.

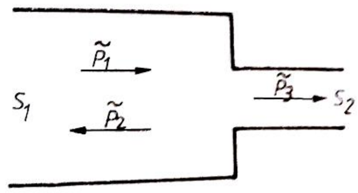

Figure 2. Power represented in the jump area

In the jump area you can write the following equation:

$$\overrightarrow{Pi} + \overrightarrow{Pr} = \overrightarrow{Pt} \qquad (4)$$

$$Pi - Pr = Pt \qquad (5)$$

As a result of comparing the volume variation in the jump area, the equation can be written:

$$S1\overrightarrow{Vi} - S1\overrightarrow{Vr} = S2\,\overrightarrow{Vt} \qquad (6)$$

Considering that $\boldsymbol{\rho\vec{V} = P}$ so $\boldsymbol{\vec{V} = \frac{P}{\rho}}$, we will have:

$$S_1\overrightarrow{Pi} - S_1\overrightarrow{Pr} = S_2\overrightarrow{Pt} \qquad (7)$$

By combining equations (5) and (7) we will have:

$$S1Pi - S2Pr = S2Pi + S2Pr \qquad (8)$$

$$Pi\,(S1 - S2) = Pr\,(S1 + S2) \qquad (9)$$

$$\frac{Pr}{Pi} = \frac{S1-S2}{S1+S2} = \frac{\frac{S1}{S2}-1}{\frac{S1}{S2}+1} \qquad (10)$$

The acoustic power transmission coefficient T becomes

$$T = \frac{S_2 P_r^2}{S_1 P_i^2} = \frac{4S1\,S2}{(S1+S2)^2} \qquad (11)$$

From the relationship it can be concluded that small section variations result in a high energy efficiency.

4.2 Concentrators with variable section

In case of sectional concentrators **ΔV = Sx dx**, the equations become less complicated by differential equations. At the end we obtain an equation of form;

$$\frac{d^2\psi}{dx^2} + \frac{d\psi}{dx}\frac{d(\ln S_x)}{dx} = \frac{1}{c^2}\frac{d^2\psi}{dt^2} \qquad (12)$$

Studying the equation we find the wavelength dependence with the section. The equation of amplitude is function of time and position in shape

$$\Psi (t, x) = \Psi (x) \sin (\omega t + \varphi) \quad (13)$$

Following the form of the exponential concentrator we find that the last third can be approximated by a cylinder, which is why the final amplitude is close to the concentrator in stages.

5. CASE STUDY

He studied the comportment of the three types of concentrators made of different duralumin - Al and OLC 45 - Ol quality steel at an amplitude of the wave at the entrance of the A_O concentrator = 8μm. The results are shown in the following Figure 3. The three types of concentrators is C1-conical concentrator, C2-exponential concentrator, C3-stepped cylindrical concentrator

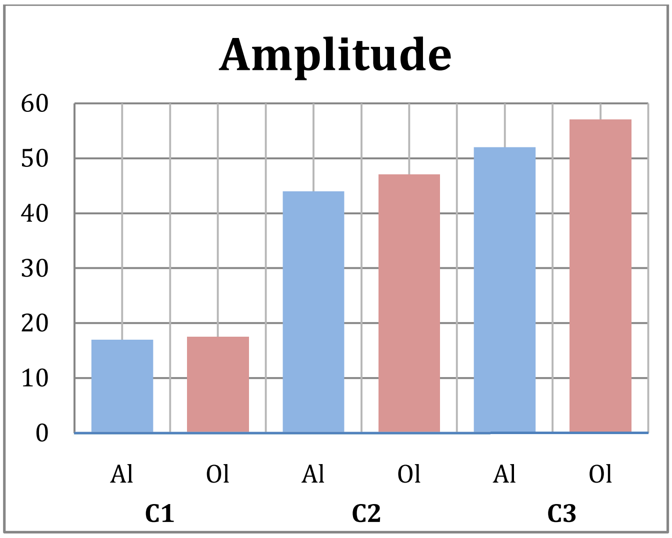

Figure3. Comparison of amplitude depending on the material and the type of concentrator

From the above we can see how wave magnitude varies in the contact area depending on the material and function of the constructive type. For the same constructive type, the higher amplitude is given by the quality steel. The measured values differ from those given by the design program, the difference, the loss in amplitude, is relatively small of 6..8%.

It has been processed with a quality steel concentrator and the three concentrator types. The work was carried out on 6 mm thick glassfor the same pressure and for 5 minutes, granulation of the abrasive particle 120μm.The results being shown in Figure 4.

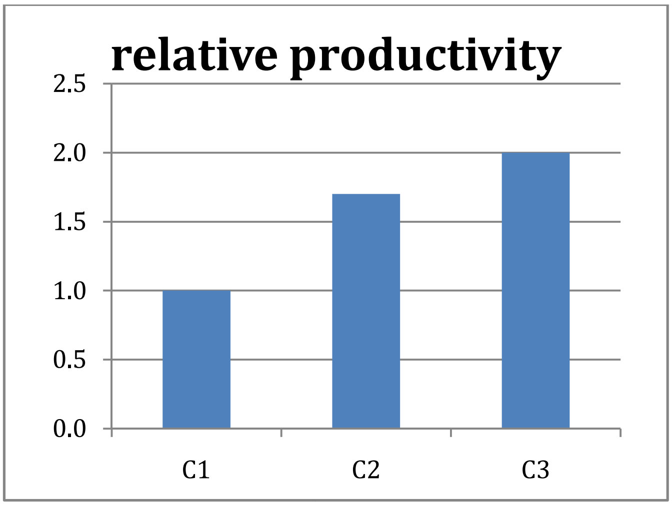

Figure 4. Relative productivity depending on the type of concentrator

In the case of the conic concentrator, this result is also poor due to its conical shape. A cylindrical head must be fitted at the top of the concentrator, resulting in a loss of power and amplitude. Head assembly is required to obtain a cylindrical bore.

The processing productivity tests for jump cylindrical concentrators of different materials were made for the same input parameters as the parameters shown in Table 1. Following the processing of the results, the following fracture shown in Figure 5 could be made.

Table 1.Concentrating characteristics

Parameters	OL 44	OLC45	stainless steel
hardness	180 HB	234 HB	50 HRC
diameter D	15,75	15,04	15,34
diameter d	4,12	4,22	4,31
length L	123,14	122,89	123,08
processed diameter	4,31	4,36	4,43
processed depth	0,85	1,23	1,32
productivity	9,92	14,68	16,27

Because we only talk about steels, the only element that can influence the processing is the concentrator's hardness. As you can see, stainless steel has the greatest influence, and the smallest rolled steel.

It can also be seen that a more precise processing is achieved in the case of stainless steel and poor machining in the case of rolled steel. So we can see a superiority of stainless steel to other materials, but also the cost price is higher.

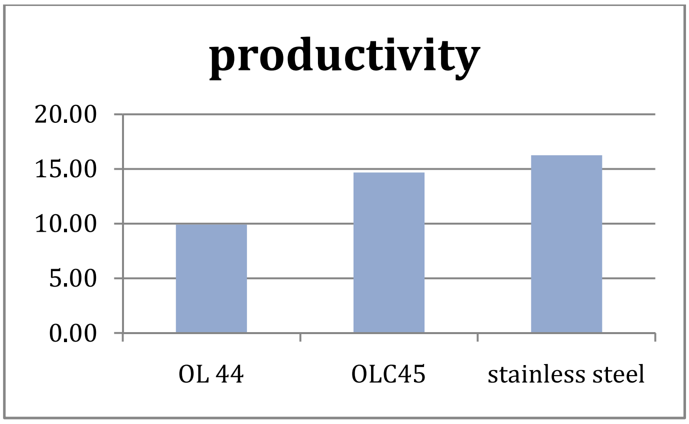

Figure 5.Productivity dependency with material type

6. CONCLUSIONS

Analyzing the conical, cylindrical, stepped, exponential concentrators, the following recommendations can be make:

1. From the constructive point of view, the easiest to achieve are concentrators in steps, conical, exponential - only on CNC machines;

2. The tool attached to the concentrator reduces the concentrator's resonance length (phenomenon encountered especially in the conic concentrator);

3. The reduction of the mechanical pressure decreases with the section and the length of the tools being higher;

4. Amplitudes of higher oscillations at the output are obtained at the compound concentrators than in the case of simple concentrators;

5. In the cylindrical concentrators, the passage areas reduce the amplification ratio, which the other concentrators do not have. To mitigate this effect, passage through the connecting rays is achieved;

6. Large cylindrical concentrators in the passage area have high mechanical stresses, which necessitates the connection of the sections;

7. The stepped cylindrical concentrator is recommended for small or medium power and semi-final operations;

8. The concentrator dissociates itself from the frequency of the transducer due to its wear;

9. Exponential concentrators provide amplifications of amplitudes greater than conical, but also higher mechanical stresses.

10. The material from which the concentrator is made must be a wear-resistant material.

11. The hardness of the material in the contact area should be of a high hardness to have a reduced wear on the concentrator.

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