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MAN'S PERCEPTION OF MECHANICAL VIBRATIONS TRANSMITTED BY WORKING PLACE

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Abstract: The perception level of man is presented in this study, and it is in conformity with specialty literature, that using the measurements of mechanical vibrations at the hand-arm system for a person, the person whom operates into places working with vibrations.
The paper demonstrated an analyze and calculus, referring the measurements effectuated about hand-arm system who are in limits. The perception level in conformity with specialty literature values are not in the limits good's, respective these are of: "good perception level" or "annoying perception level".
Keywords: Mechanical vibration, perception level, place working.

1. INTRODUCTION

It is very well to be know the perception level [1], it referring at the transmissibility of mechanical vibrations in the working place all these are very important in point of view of protection against vibration.

The measurements of accelerations [2], [3], [4] (peak) [m/s^2] were effectuated on a voluntary person, when this effectuate a cutting process on the lathe.

The acceleration (peak) [m/s^2], represents maximal magnitude at the vibration measurement [5].

$$a_{peak} = \max_{i=1}^{n} [a_i] \tag{1}$$

where:
a_{peak} – maximal magnitude of acceleration generated of vibration [m/s^2],
a_i – local magnitude of vibration moving [m/s^2].

The scheme of mechanical vibration measurements is composed by: compression piezoelectric transducer, signal amplifier in the input system, the connector for transducers, and the computer use to could see the results of measurements. The linking between measurements and the acquisition boards in computer it makes with Matlab software.

The transducer used for vibration measurements is one compression and piezoelectric, the type KD, 42 made by "Metra Mess Frequenztechnik" Germany. The transducer is fixed on skin directly, with an elastically band, into anatomical interesting points, like as: finger, wrist, elbow and shoulder.

2. HUMAN OPERATOR PERCEPTION, DUE OF MECHANICAL VIBRATIONS TRANSMISSIBILITY

The measurements of vibrations were effectuated for six rotations of machine-tool: 250 rpm (rotations/minute), 315 rpm, 400 rpm, 500 rpm, 630 rpm and 800 rpm. This perception study is important to define some dates. They are:

$$f = \frac{n}{60} \text{ [Hz]} \tag{2}$$

where: f – machine-tool frequency (Hz);
n – machine- tool rotation (rpm);

$$z = \frac{a_0^2}{f} \qquad [\frac{cm^2}{s^3}] \tag{3}$$

The relation of calculus to perception is given it by relation: [4]:

$$P = 10 \log \frac{z}{z_1} \quad [\text{pal}] \tag{4}$$

where:
z - vibration intensity [cm^2/s^3];
a_0 - acceleration magnitude (peak) [cm/s^2];
z_1 - known vibration intensity; $z_1 = 0{,}5\ cm^2/s^3$;
P - perception vibration [pal].

Table 1 *DIN 4150 [2], the vibration divides by:*

DIN 4150	
Hardly perceptible	<= 5 pal
Good perceptible	5-10 pal
Strong perceptible	10-20 pal
Annoying	20-40 pal

Also, talking of vibration effects at a person, Dieckmann introduce a coefficient of perception notated with *K* reprezentated in relation (5):

$$K = x_{ef} \frac{\gamma f^2}{\sqrt{1+(f/f_0)^2}} \quad .$$
$$K = v_{ef} \frac{\beta f}{\sqrt{1+(f/f_0)^2}} \quad ; \tag{5}$$
$$K = a_{ef} \frac{\alpha}{\sqrt{1+(f/f_0)^2}}$$

where:
a_{ef}, v_{ef}, x_{ef} - weighting acceleration [m/s^2], velocity [m/s] and displacement [m];
f = vibrating frequency [Hz];
f_0 = 10 Hz – frequency of reference;
$\alpha = 18\ s^2/mm$;
$\beta = 0.112\ s^2/mm$;
$\gamma = 0.71\ s^2/mm$.

The table 2 presents the level perception given of vibrations action about a person. The vibration perception level can be determinate of Germany norms by „VDI – Richtlinien 2057“, function of K value.

Table 3 and 4 represent intensity and perception after DIN 4150 corresponding, to vibration measurements. These vibrations regarding the human operator that work on lathe's by type SNA 580x.

Table 2 *The vibrations perception by man, function of coefficient K of perception [5].*

Perception coefficient *K*	Level	Perception level
-	A	Imperceptible
0.1	B	Hardly perceptible
0.25	C	Perceptible
0.63	D	Good perceptible
1.6	E	Strong perceptible
4	F	Very strong perceptible
10	G	Very strong perceptible
-	H	Very strong perceptible
63	I	Very strong perceptible

Table 3 *Mechanical vibration intensity for the hand-arm system.*

Z – Vibration intensity				
n (rpm)	**finger**	**wrist**	**elbow**	**shoulder**
250	49.429	7.253	7.635	10.807
315	31.795	55.436	49.557	25.453
400	45.889	12.137	7.952	16.983
500	8.086	6.743	7.265	6.238
630	13.851	4.288	4.288	3.843
800	9.174	4.709	5.783	3.305

Table 4 *The mechanical vibrations perception's for the hand-arm system.*

P – the perception vibrations				
n (rpm)	**finger**	**wrist**	**elbow**	**shoulder**
250	19.95	11.615	11.838	13.347
315	18.033	20.448	19.961	17.067
400	19.627	13.851	12.015	15.310
500	12.087	11.298	11.622	10.960
630	14.425	9.332	9.332	8.857
800	12.635	9.739	10.631	8.202

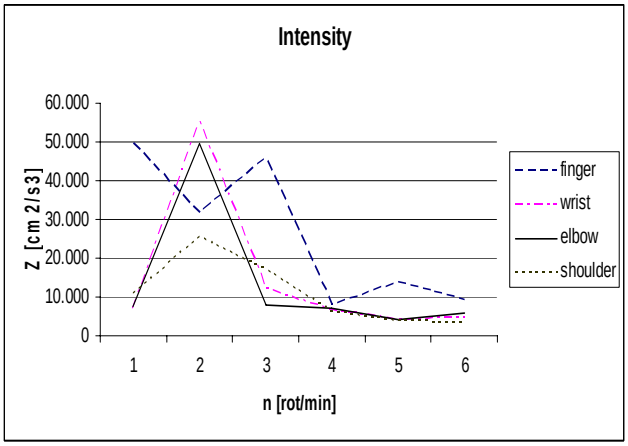

Fig. 1 - Mechanical vibration intensity.
To 1 - 6 to machine-tool rotations by: n = 250, 315, 400, 500, 630, 800 rpm

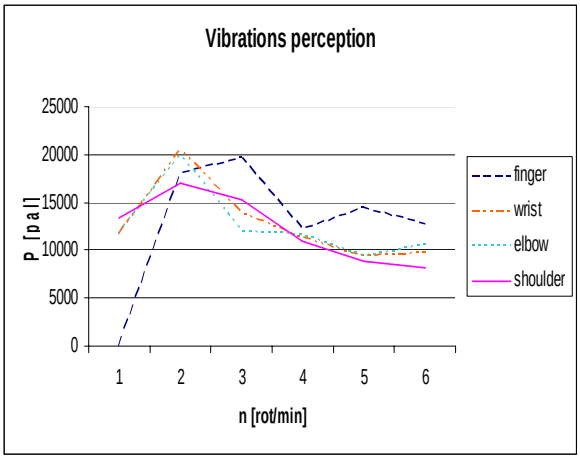

Fig. 2 - Mechanical vibration perception.
To 1 - 6 to machine-tool rotations by: n = 250, 315, 400, 500, 630, 800 rpm

The figures 1 and 2 present intensity and the vibrations perception by person's exposure in vibrations working place, all these, in conformity with measurements mechanical vibrations effectuated.

In figure 2 the bigger values for vibrations perception are obtained to 315 rpm, and these are corresponding for finger.

To all studied machine-tool rotations, the perceptibility to shoulder are decreased in comparison with other anatomical elements studied (finger, wrist, and elbow). For this a possible cause is own dumping of vibrations in the hand-arm system.

3. CONCLUSIONS

The paper demonstrated that analyze and calculus of measured vibrations to hand-arm system are in limits, but perception level, in conformity with these measurements and comparison with specialty literature values, are not good limits, respective: "good perception level" or "annoying perception level". In conformity with DIN 4150 [6], the perception level by hand-arm's vibrations is for all measurements effectuated in limits of *strong perception*, respective by 10-20 pal (Fig.1, 2).

For finger the biggest values are obtained to 315-400 rpm (Fig. 2).

In the figure 1 for wrist, elbow, shoulder the bigger values are to 315 rpm to machine-tool.

These values perceptibility level demonstrated to vibrations mechanical, these are transmitted human person enough strongly, till limits of "strongly perceptible", 10-20 pal.

The perception calculus is easy to effectuated and compared with DIN 4150, because that are standard values. Firstly, it must be measurements of vibration effectuated, respective peak or r.m.s. accelerations (root means square acceleration).

All these studies lead to protection of person exposure to mechanical vibration into the working place, because action vibration bring of negative effect up the person health, the hand, in special, it is know the Raynaud's syndrome or Vibration White Finger [6].

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Perceptibilitatea omului la vibraţiilor mecanice transmise de la locul de muncă

Rezumat: Nivelul percepţiei vibraţiilor la om este prezentat pe scurt în această lucrare. Conform cu literatura de specialitate, se evaluează acest nivel de percepere notat în lucrare cu K sau P, aceste valori fiind calculate în funcţie de măsurătorile de vibraţii la mână, măsurători efectuate pe o persoană expusă la acestea, la locul de muncă.

Studiul lucrării demonstrează atât prin calcul cât şi prin analizarea valorilor percepţiilor obţinute şi ulterior comparate cu standardele DIN 4150, că se ajunge la pragurile de perceptibilitate " bine perceptibile" şi "supărătoare", ceea ce nu e propice pentru persoana care lucrează intr-un astfel de loc de muncă, perioade mari de timp (ani).

Gradul de perceptibilitate poate fi interpretat ca o măsură de avertizare asupra pericolului expunerii la vibraţii, a persoanelor la locul de muncă, şi trebuie luate măsuri de protecţie împotriva acestora sau schimbarea locului de muncă prin alternanţă, pentru că, în caz contrar persoana se îmbolnăveşte, iar boala este considerată de natură profesională.

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