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NOISE CONTROL FOR PRESSING MACHINES. MAN-MACHINE CHARACTERIZATION

A. DRAGHICI

Politehnica Univerisity of Timisoara, Romania
e-mail: ancadraghici2003@yahoo.fr

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The paper presents the pressing machines acoustic field's research that was developed as a necessity for improving the work conditions by minimising the risk of accident and professional disease. Finally, we have established a coherent methodology for pressing machines' noise control. The efficiency and the efficacy of the proposed methodology is given by the simultaneous achievement of two aims:

1. Characterising the pressing machine's acoustic field, the sound waves flow phenomena and the acoustic field effects through the human operator by using physical and psycho–physiological parameters;
2. Identifying the pressing machine assembly that is the noise source and develop a redesign plan, by improving the man-machine interface, in this case.

1. Introduction – the research necessity and motivation

The pressing machines acoustic field's research was developed as a necessity for improving the work conditions by minimising the risk of accident and professional disease [1, 5–7]. The most SME in manufacturing industry use the pressing machines in single course exploitation because the small group of pieces that they have to make (small and middle group production). The most of the pressing machines have more years of exploitation and they suffer many maintenance processes. The main objective of our research is to characterise the acoustic field with psycho-physiological and physical parameters and to identify the machine assembly sound source that has to be re-designed.

2. The measurement diagram and the conditions used for the acoustic field investigation of the pressing machines

The measurement aims using the proposed study are: the identification of the machine's assemblies that are noise sources; the identification of the sound propagation in the external environment and the characterisation of the sound wave that flow in the area where the pressman developed his production duties.

The proposed methodology of study is a general one because it can be used for any type of pressing machine (characterised by different disposable force or with any design solution made) and using no-load operation regime or the load/full-load running one. During the experimental research in the case of the load running regime we have the possibility to identify the noise level generated by the technology – plastic deformation of the metal.

Usually, for the acoustic field characterisation [2–4, 7] we have to determine the global acoustic pressure level around the source (the pressing machine), the acoustic power level and we also need to describe the acoustic parameters for the area occupied by the worker, for the man-machine interface description. In Fig. 1 we present the measurement diagram with all the measurement points that shall be used for the acoustic field characterisation. This diagram allowed us to make: (1) the acoustic pressure global level evaluation that will create a first image of the pressing machine acoustic field and (2) the acoustic field spectral analyse by realising the spectral diagrams in a filed of frequencies from 31.5 to 31500 Hz. The measurement conditions are [2–4]:

1. For fixing the pressing machine on the foundation: all the pressing machines that will be included in the research program have to be fixed on a proper foundation and they have to be not in lapping period. They will be adjusting for the current exploitation regime.
2. For the workroom: the bay floor has to be made of cement without cover with a sound absorbent material (the absorbent parameter for 1000 Hz has to be less than 0.05). Also, the ceiling and the walls have to be at lest 1 m far from the measurement surface for avoiding the interference phenomena.
3. For the measurement: the essential condition for obtaining the right measurement data is not to have any noise in the workroom. If we can not eliminate the work

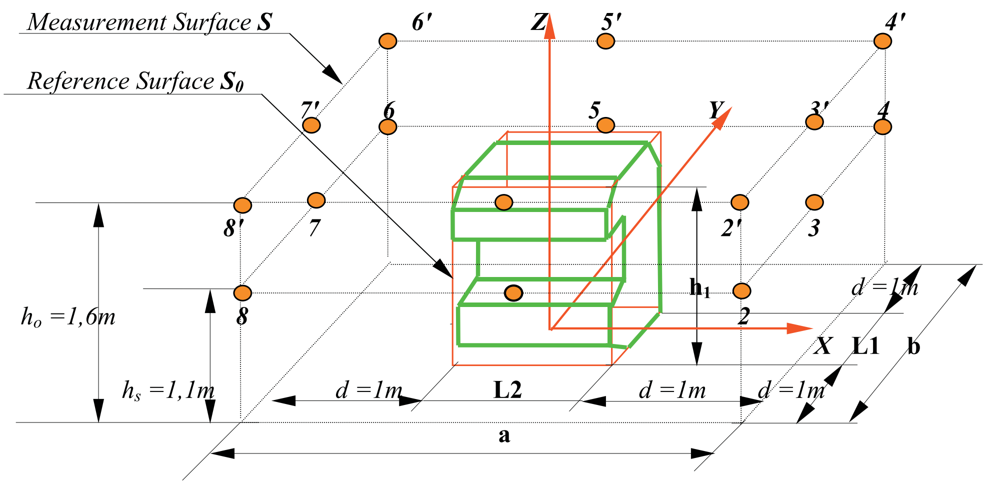

Fig. 1. Measurement diagram – the number and the place of the measurement points.

room noise we have to make some corrections considering the notation L_t for the total (general) noise level of the sound source (the pressing machine) and L_f the work room noise: if $L_t - L_f \leq 3$ dB(A), the work room is improper for the acoustic investigation and if $L_t - L_f > 3$ dB(A) and $L_t - L_f < 10$ dB(A) (for all measurement points), we have to correct the noise level of the source [1].

4. The microphone and the researcher position during the experimental investigation:
   - Between the machine and the microphone there has to be no obstacle;
   - The researcher has to be placed al lest 0.75 m from the sound level meter's microphone.

3. Experimental investigation of the pressing machine's acoustic field

At this point we will prove the utility of the proposed methodology in the context of the research necessity and motivation [1, 2]. We have structured our experimental study in 3 phases: (1) *Measurement of the global sound pressure level* L_g [dB(A)]; (2) *Spectral analyse of the acoustic field;* (3) *Measurements Verification and man-machine interface characterisation.* The conclusions of the experimental research were made by compare the measurement values of the sound pressure level were with the admitted values of this parameter. Also, the measurement values allowed us to create the global acoustic level diagrams and the spectral diagrams for the pressing machines that were study.

We shall present some experimental research and the results that we have obtained by develop the proposed methodology in the case of PMCP100 pressing machine. This is a precision pressing machine with open shaft with nominal force 1000 kN; the main shaft is parallel with the frontal face and the couple-brake assembly is pneumatic action.

3.1. *Measurement of the global sound pressure level* L_g [dB(A)]

The main objective of this phase of the experimental research was to characterise the acoustic source and to describe the acoustic field of the pressing machines, in general terms. The measurements were made based on the described methodology (Fig. 1) and using a B&K sound level meter and some examples of the first results are shown in Table 1.

In Table 1 we have use the following notations:

A – the measurements were made without a pressing operation, automate regime;

B – the measurements were made with no-load operation and single courses regime. We have separated from the global noise of the machine the shock noise made when the couple and the break are action;

C – determination were made in load running regime, pressing some iron plate $g = 1.5$ mm high and using the automate regime;

D – determination were made in load running regime, pressing some iron plate $g = 1$ mm high and using the single run regime.

Table 1. L_g [dB(A)] for the PMCP100 pressing machine (without room noise).

	Measurement points							
Measurement situation	1	2	3	4	5	6	7	8
A	83	83.3	83.8	84.1	83.5	82.2	81.5	83.2
B	96.4	95.4	96.3	96.2	96.7	101.4	102.7	102.6
C	95.7	95.2	95.3	95.1	97.5	97.8	97.8	97.4
D	98.5	97.9	97.4	97.5	98.2	102.8	103.1	102.9
The admitted value	**90 dB**							

For characterising the acoustic field we use the parameters:

1. The acoustic pressure average level on the measurement surface $\overline{L}_{p(A)}$, [4–6]:

$$\overline{L}_{p(A)} = 10 \cdot \log \frac{1}{n} \cdot \left[\sum_{i=1}^{n} 10^{0.1 \cdot L_{p(i)}} \right] - K, \qquad (1;\,2;\,3)$$

$$\text{where} \quad K = 10 \cdot \log(1 + 4S/A) \quad \text{and} \quad S = 2 \cdot (ab + ah_0 + bh_0),$$

where $L_{p(i)}$ is the acoustic pressure level in the *i point of measurement*, [dB(A)]; n – the point number for measurement, $n = 1, \ldots, 8$; K – parameter for correction; A – the absorption equivalent surface area [m^2]; S – the measurement surface area [m^2].

The absorption equivalent surface area can be determinate using the formula:

$$A = \overline{\alpha} \cdot S_v, \qquad (4)$$

where $\overline{\alpha}$ is the average acoustic absorption parameter for the work room; S_v – the area surface of the room (for the production system), [m^2], where the measurements take place.

In our experimental research the parameters that characterise the production system room are: $\overline{\alpha} = 0.15$, $S_v = 2(51 \times 13 + 51 \times 32 + 13 \times 32) = 5422$ m^2 and $A = 0.15 \times 5422 = 813.3$ m^2.

The sound pressure level value that is calculate with (1) relation has to be under the admitted value:

$$\overline{L}_{p(A)_{\text{admis}}} = 10 \log \frac{1}{n} \cdot \left[\sum_{i=1}^{n} 10^{0.1 \cdot L_{p(i)_{\text{admis}}}} \right] - K = 10 \log \frac{1}{8} \left[\sum_{i=1}^{8} 10^{0.1 \cdot 90} \right] - K. \qquad (5)$$

2. The acoustic power level:

$$L_{W(A)} = \overline{L}_{p(A)} + 10 \cdot \log \frac{S}{S_0}, \qquad (6)$$

where $\overline{L}_{p(A)}$ is the acoustic pressure level average [dB(A)]; S – the measurement surface area, [m^2]; S_0 – the reference surface considered 1 m^2.

The acoustic power level value calculate with (6) relation have to be under the admitted value:

$$L_{W(A)_{\text{admis}}} = \overline{L}_{p(A)\text{admis}} + 10 \cdot \log \frac{S}{S_0}. \tag{7}$$

Based on the measurement values of the acoustic level (that were explored in the 8 points around the machine) we have calculated the parameters shown below (Table 2) and we have represented the global acoustic level diagram (Fig. 2).

Table 2. $\overline{L}_{p(A)}$ and $L_{W(A)}$ for the PMCP100 pressing machine.

	Measurement situations			
Parameters / Admitted value	A	B	C	D
$\overline{L}_{p(A)}/\mathbf{89.6794}$	82.8240	***99.1956***	***95.8576***	***100.1881***
$L_{W(A)}/\mathbf{101.6051}$	94.7497	***111.1213***	***107.7833***	***112.1138***

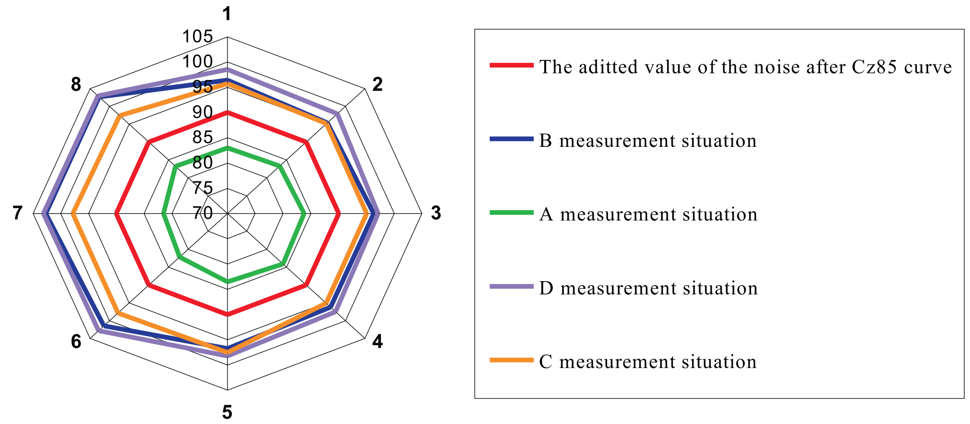

Fig. 2. The global acoustic level diagram for the PMCP100 pressing machine.

The studied pressing machine has an acoustic field that is inadequate, for the B, C and D measurement situations because the $\overline{L}_{p(A)}$ and $L_{W(A)}$ parameters are higher than the admitted values. For A measurement situation the acoustic pressure average level is under the admitted value, but this situation is not a realistic one (Table 2) and the most improper, outworn function regime correspond to D measure situation. By compare the measurement situation we can conclude that the couple and the break assembly combine with the execution of the pressing operation is the main source of noise and it generate a noise shock that is very stressed for the pressing man.

The shape of the noise diagram (Fig. 2) is very suggestive for characterising the pressing machine acoustic field. The centre of the radar graph can be assimilating with the point like noise source that is the pressing machine. So, the curves describe the noise waves around the machine. The curves for B, C and D measurement situations have a maximum that corresponds to the 7 point and the minimum correspond approximately for the opposite point. Analysing the pressing machine design we can explain this phenomena. The noise source (the couple and the break assembly) corresponds to the area where are placed the 2, 3, and 4 measurement points and here we have a low noise level. For the PMCP100 pressing machine a metal guard protects the couple and the break assembly and it's design determinate:

- the noise waves *reflection* that shall interfere with the direct waves and that's way we have increases sound pressure levels in the 6, 7 and 8 measurement points;
- the sound waves *absorption* (for the waves environment propagation waves) and that way we have small values of the sound pressure level in the area determinate by the 2, 3 and 4 points.

If we take a Fig. 2 overview we shall notice that the curves are approximately symmetric by the line consists the 3 and 7 measurement points. That can be explaining by the compact design of the pressing machine. We can appreciate that the acoustic field parameters have not maximum values in the measurement point 1 where does the pressing man occupy the position frequent of work.

3.2. Spectral analyse of the acoustic field

In the second stage of the experimental investigation of the pressing machine acoustic field we have describe more precisely the phenomena. We have measure L [dB(A)] the sound pressure level for each selected frequency from the 1/1 octave filter set, from 31.5 Hz to 31500 Hz (11 bands of frequency) for each measurement points around the machine (8 points). The measurements were made based on the described methodology (Fig. 1) and using a B&K sound level meter assembly with a B&K set of octave filters. The first results of the measurements for the PMCP100 pressing machine are shown in Table 3. Determination were made for D situation of work – load running regime, pressing some iron plate $g = 1$ mm high and using the single run regime [1, 2]. The measurement values of the sound pressure level were used for quantitative evaluation of the pressing machine's acoustic field by calculate some important parameters. Also, we have represented the spectral diagram (Fig. 3) and we appreciate the man-machine relation. For the noise harmful evaluation the calculate acoustic parameters (physical and psycho-physiological one) were compare with the admitted values that correspond to the Cz85 noise curve that is recommended for medium attention stress conditions of work (ISO 1999). So, the work place noise is consider to be no harmful if each point of it's spectrum curve do not overrun the Cz noise curve that is recommended for this work place.

For characterising the acoustic field effects we have determinate the continuous equivalent acoustic level L_{eqc} that represents a constant noise acoustic level, in dB(A), that continuous acting during the whole week of work has the similar audible effect like

Table 3. L [dB(A)] measurement values for the PMCP100 pressing machine (D – measurement situation).

			Measurement points			
The bande frequency [Hz]	The room noise [dB(A)]	L[dB(A)] Admitted value after Cz85 curve	**1**	**2**	**3**	**4**
31.5	62	***110***	85.4	85.7	86.4	84.3
63	61.5	***103***	84.9	85.3	86.7	83.7
125	60.8	***96***	85.8	84.6	86.8	83.3
250	60.4	***91***	85.9	85.3	86.2	83.9
500	59.7	***88***	85.6	84.9	86.4	83.6
1000	59.2	***85***	***85.4***	84.7	***86.3***	84.1
2000	58.9	***83***	***86.2***	***85.1***	***86.9***	***83.6***
4000	59	***81***	***86.1***	***84.6***	***87.1***	***83.9***
8000	58.6	***80***	***85.6***	***84.2***	***87.2***	***84.9***
16000	57.2	***79***	***85.9***	***84.5***	***87.1***	***84.8***
31500	58.4	***78***	***85.8***	***83.8***	***87.4***	***84.6***
L_{eqc} [dB(A)]	68.9049	***90***	88.9608	88.9608	88.9608	88.9608
L_g [dB(A)]	68.2	***90***	85.5	84.5	86.8	84.5
Λ [foni]	80	***90***	***105***	***104***	***107***	***104***
S [soni]	***15.78***	***32***	***92.6***	***85.2***	***101.1***	***82.8***
			5	**6**	**7**	**8**
31.5	62	***110***	84.5	84.7	84.8	84.9
63	61.5	***103***	84.2	84.5	84.5	84.5
125	60.8	***96***	83.8	84.5	84.4	84.2
250	60.4	***91***	84.4	84.7	84.3	83.9
500	59.7	***88***	84.8	85.2	84.2	83.5
1000	59.2	***85***	84.4	84.9	84.0	84.4
2000	58.9	***83***	***84.2***	***84.4***	***84.4***	***83.9***
4000	59	***81***	***84.5***	***84.9***	***84.8***	***83.8***
8000	58.6	***80***	***84.3***	***84.5***	***84.7***	***83.9***
16000	57.2	***79***	***84.8***	***83.9***	***84.1***	***84.2***
31500	58.4	***78***	***84.9***	***83.7***	***83.8***	***83.9***
L_{eqc} [dB(A)]	68.9049	***90***	88.9608	88.9608	88.9608	88.9608
L_g [dB(A)]	68.2	***90***	84.8	84.5	84.3	84.5
Λ [foni]	80	***90***	***104***	***105***	***104***	***102***
S [soni]	***15.78***	***32***	***84***	***89.1***	***82.3***	***75.2***

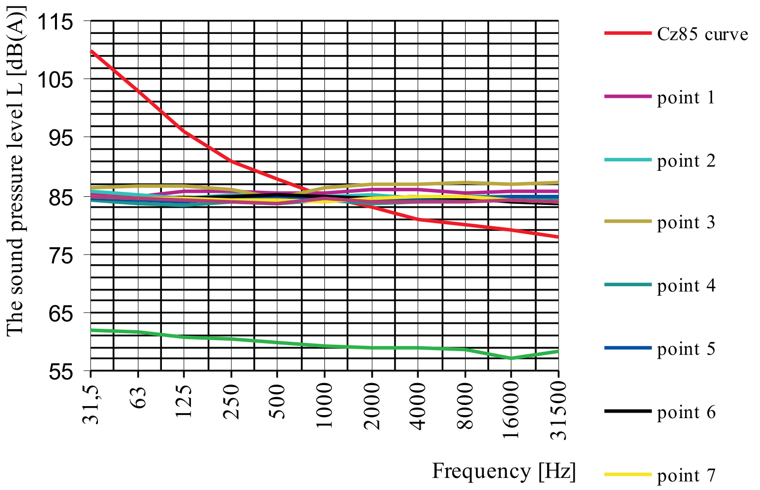

Fig. 3. The spectral diagram for the PMCP100 pressing machine.

the source noise effect. The calculation relation is:

$$L_{\mathrm{eqc}} = 10 \cdot \log \left[\text{anti}\log \frac{L_{63}}{10} + \text{anti}\log \frac{L_{125}}{10} + ... + \text{anti}\log \frac{L_{8000}}{10} \right] \mathrm{dB(A)}, \quad (8)$$

where $L_{63}, L_{125}, \ldots, L_{8000}$ are the corrected sound pressure level for the 63 Hz, 125 Hz, ..., 8.000 Hz frequency from the octave filter.

The measurement values of the sound pressure level are corrected by knowing the pressing man's week exposing duration to noise. The calculate value L_{eqc} has to be under the admitted value of the acoustic pressure level (90dB(A)) that correspond to Cz85 curve.

The man-machine interface, from the noise perception point of view, can be appreciate by using the psycho-physiological parameters: the loudness level Λ [phon] and the loudness S[sone]. The calculations that are made in this case are based on the following formula:

1. The total loudness level Λ_T and the total loudness S_T, permit us to build a noise scale based on the human operator perception of the phenomena. For the parameter's calculation we use a graph from where we determine: N_i the loudness indices for each i frequent of the 1/1 octave. Than we can calculate S_T using the formula:

$$S_T = N_m + K \cdot \left(\sum_{i=1}^{n} N_i - N_m \right) \quad \text{[sone]}, \quad (9)$$

where N_m is the biggest value of the loudness indices, choose from the graph; N_i – the loudness indices for the i frequent of the 1/1 octave; n – the number of the 1/1 octave bands; K – parameter for the octave filter type that was used in the experimental research; in our case $K = 0.3$.

For the total loudness level we use the following algorithm:

$$S_T = 2^{(\Lambda_T-40)/10} \Leftrightarrow \log S_T = \frac{\Lambda_T - 40}{10} \cdot \log 2 \Leftrightarrow \Lambda_T = 10 \cdot \left[4 + \frac{\log S_T}{\log 2}\right]. \quad (10)$$

The admitted value of the loudness level is 90 phon and 32 sone for the loudness, correspond to the Cz85 curve.

The Λ_T and the S_T parameters are practically used to appreciate the noise effect on human body, in fact the noise perception. During our scientifically research we have calculate both parameters because the scientific report has been evaluate by different specialist in design and manufacturing of the pressing machines.

From the spectral diagram we can conclude that the Cz85 noise curve is overrun from the frequencies higher than 1000 Hz so the acoustic field is harmless for the pressing man. We can see that the curves for each measurement point have the same tendency (the curves are concentrate in a filed of 83.3 Hz to 87.4 Hz) and that's because of the pressing machine's compact design. Following the evaluation of the parameters presented below, here are the results of the calculations:

Table 4. Calculation of L_{eqc} parameter.

Measurement points	The noise level dB(A) for the frequencies [Hz]							
	63	125	250	500	1000	2000	4000	8000
1	84.9	85.8	85.9	85.6	85.4	86,2	86.1	85.6
2	85.3	84.6	85.3	84.9	84.7	85.1	84.6	84.2
3	86.7	86.8	86.2	86.4	86.3	86.9	87.1	87.2
4	84.9	85.8	85.9	85.6	85.4	86.2	86.1	85.6
5	84.2	83.8	84.4	84.8	84.4	84.2	84.5	84.3
6	84.5	84.5	84.7	85.2	85.9	84.4	84.9	84.5
7	84.5	84.4	84.3	84.2	84	84.4	84.8	84.7
8	84.5	84.2	83.9	83.5	84.4	83.9	83.8	83.9
Corrections	82	82	82	82	82	82	82	82
Correction of weighting	−26	−16	−9	−3	0	+1	+1	−1
Results	56	66	73	79	82	83	83	81

$$L_{\text{eqc}} = 10 \cdot \log \left[\text{anti}\log\frac{56}{10} + ... + \text{anti}\log\frac{81}{10}\right]$$

$$= 88.9608 \text{ dB(A)} < 90 \text{ dB(A)} = L_{\text{eqc}}^{\text{admis}}. \quad (11)$$

Considering this parameter of the acoustic field characterising the pressing machine seems to be proper for using.

For al the measurement points the admitted values of the loudness level ($S_{\text{admitted}} = 32$ sone) and of the loudness ($\Lambda_{\text{admitted}} = 90$ phon), too. So, the PMCP100 pressing machine has a great risk for work disease using the criteria of the human operator noise perception. There can be identified two elements that generate this risk: first, the sound pressure level (physical parameter) that overrun the admitted value after the Cz85 noise curve and second, the sound propagation phenomena – there are noise shocks during the pressing machine function. Also, the psycho-physiological parameters confirm that the pressing machine work place is a stressed one. The effects of the noise perception under the pressing man were very suggestive indicate by the medical report [1, 2].

Table 5. Λ and S_T determinated for the studied pressing machine.

Measurement points	Loudness indices for the frequency [Hz]								S_T [sone]	Λ_{chose} [phon]
	63	125	250	500	1000	2000	4000	8000		
1	10	14	16	20	24	30	38	47	**92.6**	**105**
2	10	12	16	18	23	30	35	42	**85.2**	**104**
3	11	13	17	20	24	32	40	54	**101.1**	**107**
4	8	11	15	16	20	24	32	45	**82.8**	**104**
5	9	11	14	16	21	25	34	45	**84**	**104**
6	9	13	16	20	24	27	38	45	**89.1**	**105**
7	9	13	14	18	23	27	37	40	**82.3**	**104**
8	9	12	15	16	22	25	25	38	**75.2**	**102**
Room's noise	1.6	2.5	3.5	4	4.5	5.3	6.2	7.5	15.78	80

Table 6. Λ calculated using (10) relation.

Measurement points	Λ Calculated [phon]	Measurement points	$\Lambda_{\text{calculated}}$ [phon]
1	**105.3294**	5	**103.9232**
2	**104.1278**	6	**104.7735**
3	**106.5964**	7	**103.6282**
4	**103.7156**	8	**102.3266**
The room's noise	79.8002		

3.3. Measurement verification and man-machine interface characterisation

In the third phase of the pressing machine's acoustic field investigation we have used the same methodology (Fig. 1) of work and Quest 2800 sound level meter. The Quest 2800 functions as a sound level meter, impulse or integrating sound level meter. In all modes the Quest 2800 delivers Type 2 accuracy for noise measurements and statistical analysis. This hand held meter is user friendly and has a direct digital LCD display that shows numerical and bar graph measurements.

The parameters that were display by QUEST 2800 are: SPL – the sound pressure level that was continuous indicate by the apparatus. The SPL nominal value was adjusted with the atmosphere pressure at the sea level (760 mmHg) and so the altitude and the atmosphere pressure do not have influence on the measurement values; MAX – the maximum level of the sound pressure; MIN – the minimum level of the sound pressure; SEL – the sound exposure level for a accumulate average sound that have a duration of 1 second; TIME – the time for measurements; LEQ – the equivalent sound pressure level or the average level of the investigated sound, that is integrated and accumulated during the measurements. Some examples of the measurement process results are shown in Table 7.

Table 7. Results of the measurements.

In the moment of the couple and break action; the placed level of the microphone $h = 1.1$ m								
	1	2	3	4	5	6	7	8
MAX [dB(A)]	98.9	94.4	97.1	95.2	95.2	103.8	103.1	104.2
MIN [dB(A)]	69.7	71.9	88.4	72.3	76.1	71.9	71.9	71.9
SEL [dB(A)]	93.2	89.4	95.8	91.8	92.4	97.1	96.8	97.6
TIME [s]	$4''$	$4''$	$4''$	$4''$	$4''$	$4''$	$4''$	$4''$
LEQ [dB(A)]	85.5	83.8	88.4	84.7	86	91	90.3	92.1
The admitted value of the sound level after Cz 85 noise curve is 90 dB (manufacturing rooms with medium stress)								

The measurement parameters were analyse by representing them in diagrams (for example: Fig. 4). Than we made the following calculation of *the noise dose* (ND%) which is a parameter that correlates the sound pressure value with the risk for professional diseases that occurs as a result of the human operator exposure to sound stress during s determinate period of time. The admitted value of the ND% is 100%. The LEQ measure parameter will be converted into noise dose by using a corespondent graph.

Analysing the diagram shape we can conclude that:

- in the automate function regime of the pressing machine LEQ parameter is under the admitted value after the Cz85 noise curve. This is a proper function regime for this type of the machine;
- The noise diagram in the moment of the couple and break action (Fig. 4) has proved the existence of a noise shock. So, the single courses running regime is dangerous for the human operator (risk for professional disease).

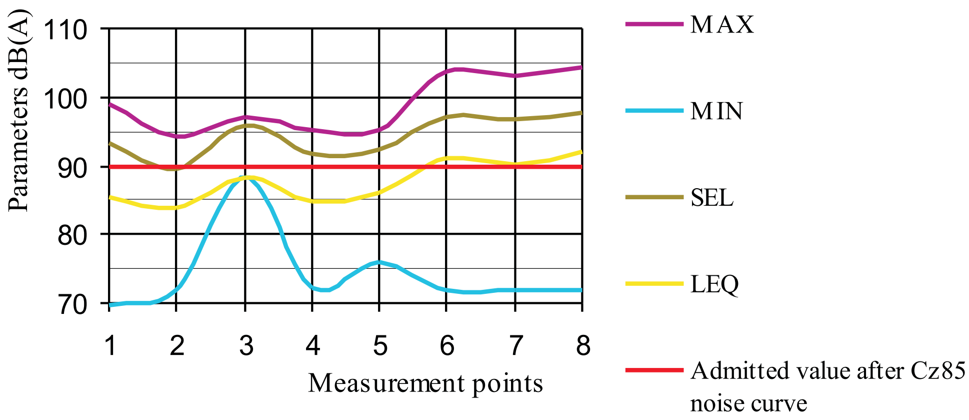

Fig. 4. Noise diagram in the moment of the couple and break action; the placed level of the microphone $h = 1.1$ m; measurement time 4 s.

For characterising the man-machine interface and the influence of the pressing machine function under the human operator we have calculate the noise dose (Table 8) for the position often occupied by him (measurement point 1).

We can conclude that the automate function regime of the PMCP100 pressing machine is no dangerous for the human operator. The single curses function regime has to be avoid as possible. Also, the couple and break design has to be optimising under the noise-emitted criteria. The measurements and the conclusions that were made in the first and second phases of the research have been evaluated in the third phase. The observations and the conclusions that were presented confirm that the noise source is the couple and the break assembly (no-load operation). In full-load running regime the noise of the couple and the break is doubled by the noise of the plastic operation that is developed.

Table 8. ND% for the 1 measurement point.

Measurement situation	LEQ [dB(A)] / The room noise	Noise exposure [hour]	ND %	Conclusions:
A* $h = 1.1$ m	82.1 / 70	5 / 3	10 / 3	The work conditions are no dangerous
$\sum$	$82.1 + 0.3 = 82.4$ dB(A)	8 ore	$13 < 100$	
A* la 4m şi $h = 1.1$ m	79 / 70	5 / 3	9 / 3	The work conditions are no dangerous
$\sum$	$79 + 0.3 = 79.3$ dB(A)	8 ore	$12 < 100$	
A* $h = 1.6$ m	82.7 / 70	5 / 3	11 / 3	The work conditions are no dangerous
$\sum$	$82.7 + 0.4 = 83.1$ dB(A)	8 ore	$14 < 100$	

*) A – automate function regime.

4. Conclusions

The acoustic field's studies for pressing machines has been developed to attempt the industrial need for this work systems optimisation. The proposed methodology integrated the principles, methods and means of work safety management such as to obtain a significant increase of the reconceived man-machine system safety in particular for the pressing machines. The strategy of approach of the man-machine system, in this case, regardless of its particularities has for a general objective the optimisation of the means of production by creating a relationship of correct proportionality with the human subsystem. The efficiency and the efficacy of the proposed methodology is given by the simultaneous achievement of two aims: (1) Characterising the pressing machine's acoustic field, the sound waves flow phenomena and the acoustic field effects through the human operator by using physical and psycho-physiological parameters; (2) Identifying the pressing machine assembly that is the noise source and develop a re-design plan, by improving the man-machine interface, in this case. The proposed methodology integrated the principles, methods and means of work safety management such as to obtain a significant increase of the reconceived man-machine system safety in particular for the pressing machines. The strategy of approach of the man-machine system, in this case, regardless of its particularities has for a general objective the optimisation of the means of production by creating a relationship of correct proportionality with the human subsystem.

The proposed methodology was implemented, evaluated and tested in the concrete case of a vast scientific research project focusing on the ergonomics re-design of open frame mechanical presses [2]. The research result consists of the existing man-pressing machine optimisation with low costs and great improvements of the work conditions.

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