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NOISE AND VIBRATION EVALUATION OF WATER JET MATERIAL CUTTING WORKING SURROUNDINGS

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ABSTRACT:
The global environmental trends lead to utilizing of so called „clean technologies“ with minimum environmental impact. In case of high-speed continual waterjets application it is possible to expect substantial raise of products manufacturing efficiency.
KEYWORDS:
Noise and vibration in waterjet material separation conditions and their impact to production process logistics.

1. INTRODUCTION

Abrasive waterjet technology (AWJ) will be researched from aspect of environmental integration, behaviour and infuences. Noise and vibration evaluation in working conditions of waterjet material separation will be carried out from aspect of technology, relations, interactions, inputs, time, outputs and consequences. The goal is noise and vibration evaluation during cutting process in one working shift. Environmental relations complications and their impact are expressed by material flow productivity in real time and space.

Systematic environmental approach has not been applied for AWJ technology, yet. Anthroposofy impact has neither been analysed from aspect of permanenly sustainable impact to AWJ operators´ health. For example, occurence of job-related ilnesses related toLegionella Pneumophilia or Silicosis occurence has not been surveyed systematically, meantime AWJ technology energy demands are relatively high. Rather high rate of not-adequate environmental load of working conditions is related to humid and dusty climate, to sewage water and to abrasive material that remain after waterjet cutting.

WATING Prešov is situated in a hall of plane construction. The working site consists of three separated areas, the area (A) represents production and technological part of the working site, the control centre is located in area (B) and in area (C) there is arelaxing room for working site operators. – Fig. 1.

2. DESCRIPTION OF PRODUCTION PROCESS

The working place serves for water-jet material cutting process. Almost all kinds of technical materials (brass, rustfree metals, steel, alluminium, marble, granite, glass, plastics, plexi-glass, ceramics and others) with area dimensions up to 2,0 x 3,0 m and thickness up to 150 mm are cut here. It is a custom-made piece production. The material to be processed is delivered by a customer and the customer takes waste away as well. The average production varies from one to several hundreds pieces a day. Technology of high-speed and high-pressure water jet with minimum consuption of water is used for cutting and gravuring. The cutting is either with water without abrasives by method WATERNIFE (soft materials) or by method PASER with natural garnet granules with dimesnions of cca 0,14 inch as abrasives (other materials). The source of the water jet is a high-pressure pump with a multiplicator

and output water pressure up to 400 MPa. Water conducted in a special high-pressure head runs into cutting head with speed up to 1 000 m/sec. Abrasive material goes through a special hose into the cutting head. Cutting is done on a coordinate desk by the cutting software controlled head. A bath with water is a part of the coordinate desk. The water column eliminates water jet energy. On the working place there are two coordinate desks. In the time of measuring, sheets of cast ceramics of thickness 8 mm and rustproof steel sheets of thickness 10 mm were being cut.

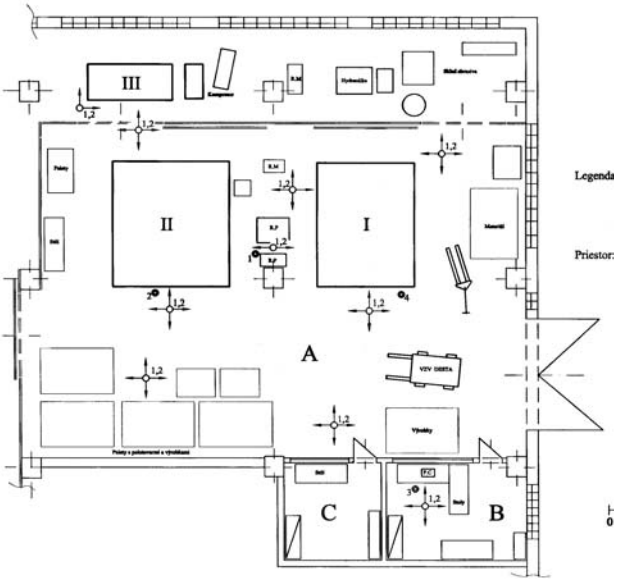


Fig. 1: A block plan of measuring places: Watting Prešov s.r.o., – water jet cutting operation
Legend:
- measuring place with worker
- motion marking
- stationary measuring places (noise pollution)

I - Coordinate desk W 32 BN
II - Coordinate desk W 315 BN
III – high-pressure pump with multiplicator SL II HP
Area:
A – material cutting
B – control centre
C – common room
Scale: 1 : 100

3. DESCRIPTION OF WORKING PROCESS

The prevailing activity of the head of the water-jet cutting working place is orders receiving and hanging out, paperwork, cutting programmes preparation including blueprints and controlling programme preparation. The worker carries out all changes and adjustments of machine device related to an order.

The prevailing activity of cutting machines operators is the coordinate desk operation and visual checking of cutting, monitoring of cutting technological process, machine adjusting before a new product manufacturing, operating with cut material, lift-truck operating, material and products discharge and delivering.

During one shift running, 3 people work with water-jet cutting (one of them is a chief – a computer programmer and two of them are cutting machines operators). The beginning of the shift is at 06:30 and the end is at 02:30 PM. The break is from 10:00 till 10:30.

4. MEASURING METHODS AND USED DEVICES

A method of characterization activities measuring samples was used for evaluation of noise exposition of workers exposed to variable noise with statistic dynamics of 15,6 – 17,1 dB during water-jet cutting. The measuring microphone has been situated on the exposed worker. In the same time, noise pollution on various places and special noise characterisics have been measured.

Table 1. Used measuring devices

KIND	TYPE	PRODUCER	PRODUCTION CODE	ACCURACY CLASS	SET FUNCTIONS
phonometer	2231	B& K	1178 410	1	BZ 7115, LAeq, I-N
microphone	4155	B& K	1215 295	-	49,5 mV/Pa
accoustics gauge	4230	B& K	1233 624	1	L=94,0 dB/1 kHz
Phonometer	2260	B& K	2418 371	1	BZ7219, LAeq
microphone	4189	B& K	2417 797	-	51,7mV/Pa
noise exposure meter	SIE 95	01 dB STELL MVI	30 345	2	LAe9, LCPk, T„t1,0S
noise exposure meter	SIE 95	01 dB STELL MVI _	30 335	2	LAeq, LcPk, T;nt1,0s

5. RESULTS OF MEASURING

a) Description of exposition by kinds of done works

After workers motion monitoring it is clear that cuting machines operators stay for prevailing part of the shift at coordinate desks where they check material separating process visually, adjust machinery, lay and fasten cutting material and carry out other preparation and manipulation works. Partial noise loading at those working activities expressed by noise exposition level within 3 – 30 minutes varies from 82,2 to 88,3 dB. According to measurement data, this activity lasts in average for 427,5 minutes. During the rest part of the shift the workers stay at the control centre.

The programmer prepares cutting programmes on the computer for prevailing part of the shift, develops the blueprints and processes administration. Partial noise loading at those working activities expressed by noise exposition level within 3 – 30 minutes varies from 57,8 to 63,4 dB. According to measurement data, the programmer stays at control centre in average for 427,5 minutes. During the rest part of the shift he carries out works at cutting machines.

Table 2. Samples of noise exposition of workers by individual working activities

WORKING ACTIVITY	TIME OF MEASURING T (s)	EA T (Pa's)	LEx,T (dB)	LcPk,T (dB)	LPk,T (dB)	LAmax (dB)
Checking and adjusting otechnological cutting parameters on control unit	65 336	8 19	85,0 81,7	106,8 108,6	- -	90,3 92,1
Checking and adjusting technological cutting parameters on control unit, programming and developing blueprints on PC	386 1 037	9 17	77,9 76,3	123,4 113,0	- -	95,1 96,3
Ceramics sheet laying on the coordinate desk, machinery and pump adjusting	454 159 705	31 16 59	82,4 84,2 83,3	129,4 108,0 119,2	- - -	100,4 93,4 97,7
Visual checking of ceramics sheet cutting, laying of cut material on the pallet, laying of the sheet on the coordinate desk, checking of the pump	402 221 400	18 13 50	80,6 81,9 85,0	111,4 112,2 113,6	- - -	91,9 92,1 101,1
Programming and carrying out blueprints on PC	875 1 414 1340	1 0 0	64,6 62,0 60,5	117,6 104,6 105,3	- - -	88,4 79,8 76,6
Laying of cutting material on the pallet, dimensions checking, laying of the ceramic sheet on the coordinate desk, checking of the pump andcutting process, programming and carrying out blueprints on PC	1616	55	79,4	116,2	-	94,6
Visual checking of rustfree sheet cutting, checking and adjusting of technological cutting parameters on the control unit	958	72	82,8	109,6	-	96,7
Visual checking of rustfree sheet cutting, picking and laying of the cut materail, laying of the rustfree sheet on the coordinate desk, pump pressure reducing	420	79	86,8	124,4	-	100,8

Total time measuring interval T = 176 min 48 sec (represents complete standard time interval)

Table 3. Samples of noise exposition of workers by individual working activities

WORKING ACTIVITY	TIME OF MEASURING T (s)	EA T (Pa's)	LEx,T (dB)	LcPk,T (dB)	LPk,T (dB)	LAmax (dB)
Laying of the ceramic sheet on the coordinate desk, ajusting of machinery and pump, checking of rustfree and ceramic sheets cutting, cleaning and laying of cutting material on the pallet.	1 260 1 560 1 800	195 235 229	85,9 85,8 85,1	116,8 120,0 117,8	- - -	101,7 101,8 101,0
Adjusting of technological parametres for ceramic and rustfree sheets cutting, on the control unit, laying of the ceramic and rustfree sheets on the coordinate desk, cleaning and laying of the cutting material on the pallet, cutting material checking by measuring, pouring of abrasive material into bags, cutting visual checking, picking and laying of the cut material,	1 740 1 500 1 546 1 547	174 174 263 282	84,0 84,7 86,3 86,6	118,0 123,4 118,8 114,6	- - - -	118,0 101,9 103,1 102,5

Total time measuring interval T = 182 min 33 sec (represents complete standard time interval).

b) Evaluating level A of noise determined by direct measuring at individual working activities during 7,5 hours of the shift. The programmer stays at cutting machines for 135 minutes and operator 427,5 minutes (Table 4).

Table 4. Evaluating level A of noise determined by direct measuring

WORKING ACTIVITY	$L_{Ar,an}$ (dB)	$E_{A,g,,}$ (Pa^2s)
Checking and adjusting of technological parametres for cutting on the control unit, programming and working out blueprints on PC, ceramic and rustfree sheets cutting visual checking, laying of the cutting material on the pallet, laying of the ceramic and rustfree sheets on the coordinate desk, pump checking, dimensions checking, picking and laying of the cut material	79,6	1 049
Adjusting of technological parametres for ceramic and rustfree sheets cutting, on the control unit, laying of the ceramic and rustfree sheets on the coordinate desk, cleaning and laying of the cutting material on the pallet, cutting material checking by measuring, pouring of abrasive material into bags, cutting visual checking	87,4	6 325

NOISE POLLUTION

a) Working places and pollution quantity (Table 5).

Table 5. Working places and pollution quantity

NUMBER OF MEASURING PLACE	MEASURING PLACE DESCRIPTION	MEASURING TIME T (min)	LAeqT (dB)	LcPk,T (dB)	Lpk,T (dB)	LA,,,. (dB)	LA,,,,. (dB)
1	Cutting machine control unit	3 min	83,2	116,1	109,7	94,4	64,9
		3 min	85,2		110,5	95,2	66,8
		3 min	82,2		107,0	93,2	67,8
		3 min	83,1		108,8	95,0	68,0
2	Coordinate desk W 32 BN	3 min	82,5	111,9	113,4	95,3	63,1
		3 min	88,1		119,0	105,0	66,3
		3 min	86,7		115,9	103,6	65,7
		3 min	87,2		114,5	97,4	64,3
		3 min	87,8		120,2	105,9	64,5
3	Control centre	3 min	57,8	101,3	91,2	71,7	44,1
4	Coordinate desk W 315 BN	3 min	86,6	118,4	118,6	100,4	65,8
		3 min	86,2		116,5	100,0	66,5
		3 min	87,0		117,1	99,9	66,4
		3 min	88,3		114,4	97,1	64,5

b) Equipollent levels of accoustic pressure in frequency bands within 1/3 octave width

Table 6. Equipollent levels of accoustic pressure

NUMBER OF MEASURING PLACE	EQUIPOLLENT LEVELS OF ACCOUSTIC PRESSURE (dB) IN FREQUENCY BANDS WITHIN 1/3 OCTAVE WIDTH (Hz)									
	20	25	31,5	40	50	63	80	100	125	160
1	-	62,4	54,2	58,5	71,0	56,7	57,4	60,9	59,1	59,6
2	53,3	66,5	53,1	58,3	68,7	56,1	59,5	61,1	55,9	59,6
3	52,4	57,9	50,2	56,7	55,9	51,4	49,6	45,6	41,0	35,0
4	51,4	65,5	53,6	59,5	63,3	55,7	59,2	62,7	57,2	57,9

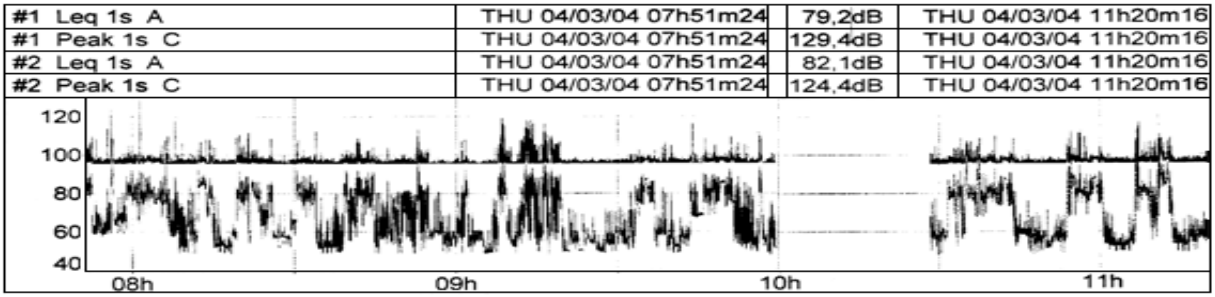
NUMBER OF MEASURING PLACE	EQUIPOLLENT LEVELS OF ACCOUSTIC PRESSURE (dB) IN FREQUENCY BANDS WITHIN 1/3 OCTAVE WIDTH (Hz)										
	200	250	315	400	500	630	800	1000	1250	1600	2000
1	64,2	66,1	60,8	62,5	62,1	66,6	65,5	65,5	66,0	67,5	68,6
2	60,3	64,7	63,4	65,3	69,0	65,2	63,2	60,6	62,7	64,3	67,1
3	38,0	40,4	40,0	41,2	42;5	44,9	42,7	41,6	42,3	43,2	43,0
4	60,5	67,8	62,2	65,3	63,9	67,0	66,1	67,2	68,3	69,0	70,4

NUMBER OF MEASURING PLACE	EQUIPOLLENT LEVELS OF ACCOUSTIC PRESSURE (dB) IN FREQUENCY BANDS WITHIN 1/3 OCTAVE WIDTH (Hz)									
	2500	3150	4000	5000	6300	8000	10000	12500	16000	20000
1	69,3	69,9	70,4	71,6	72,3	71,4	70,4	69,5	68,9	65,8
2	67,5	69,1	70,4	75,1	77,3	76,1	77,6	78,5	80,4	80,5
3	44,1	45,6	45,9	46,2	45,2	41,7	40,4	37,4	34,9	30,1
4	70,8	71,0	72,1	74,2	76,1	76,7	78,2	79,5	81,0	80,1

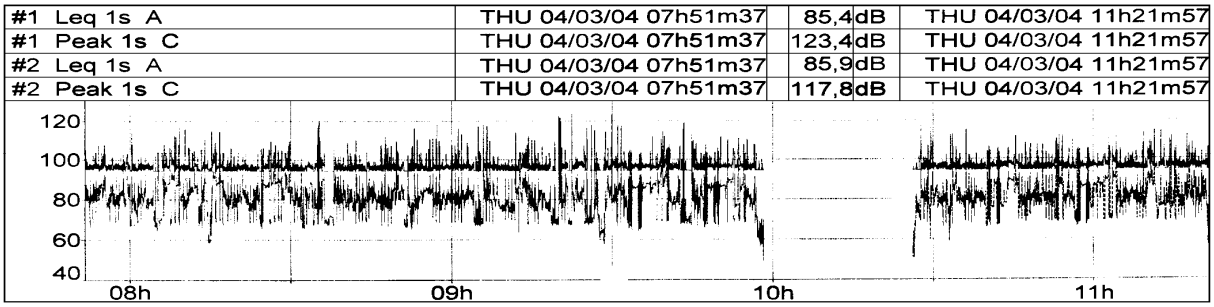
6. MEASURING GENERAL EVALUATION

A. Noise exposition of workers during water jet cutting operation (diagrammatic illustration)

A personal experiment no. 1 - Checking and adjusting of technological parametres for cutting on the control unit, programming and working out blueprints on PC, coordinate desk operation at ceramic sheet cutting (Table 6).



A personal experiment no. 2 – Ceramic and rustfree sheets cutting technological parametres adjusting on the control unit, coordinate desks and pump operation (Table 7).



B Percentage levels (Table 8).

MEASURING SITE	MEASURING INTERVAL	L_1 dB(A)	L_{10} dB(A)	L_{50} dB(A)	L_{90} dB(A)	L_{99} dB(A)
1	3 min.	92,5	85,5	82,0	69,0	65,5
	3 min.	93,5	86,5	85,0	68,0	67,0
	3 min.	90,5	85,5	81,0	69,0	68,5
	3 min.	92,0	85,5	81,0	76,5	68,0
2	3 min.	92,0	85,5	80,0	69,5	64,0
	3 min.	96,5	88,5	86,5	67,5	67,0
	3 min.	94,0	89,0	84,5	68,0	66,5

The workers duringwater jet cutting are esposed to audible sound of fluctuating characker with statistic synamics of 15,6 – 17,1 dB. The acoustic spectrum of cutting device W 315 BN contains a tonal component within frequency area of 25 Hz. The total acoustic exposition of the workes expressed by evaluating level A of the sound within 8 hours varies from 79,6 to 87,4 dB. The summit level C of the sound determined during normalized/standard time interval varies from 123,4 to 129,4 dB.

The works carried out at material water jet cutting (for technical, organization and other arrangements) are ranked according to Government decree no. 40/2002 to group no. VI with maximum allowed evaluating level A of sound L = 85 dB. From the point of view of interfering noise in the control centre at programming and carrying out blueprints on PC it is ranked to group no. IV with maximum allowed normalized level of noise expostion L = 60 dB. The maximum alloed top level C of the sound L on the working sites is 140 dB.

The resulting extended measuring unstableness with index of covering k = 2 considering device accuracy, frequency composition and measured sound directional features U, = 3,6 dB (noise exposition), = 2,3 dB (noise pollution).

According to measuring results the evauating sound level A extended into measuring unstableness is at cutting machines operators higher than maximum allowed value (L,q,+U > NPH). The evaluating sound level A extended into measuring unstableness is at programmer less than maximum allowed value (L + U < NPH). The top sound level C extended into measuring unstableness is less that maximum allowed value (Lc + U < NPH). To sum up, the total sound exposition of cutting machines operators expressed by evaluating sound level A exceeds the maximum allowed value. The total sound exposition of the programmer expressed by evaluationg sound level A is not exceeded. The top sound level is not exceeded.

Noise measuring and evaluating has been carried out in accordance to Government decree of the Slovak Republic no. 40/2002 on health rotection from noise and vibrations. During measuring the workers used a personal ear protectors EAR.

7. CONCLUSION

According to measurements it arises that summary acoustic exposition to cutting machine operators expressed by evaluating sound level A exceeds maximum allowed level. The summary acoustic exposition of programmer expressed by evaluationg sound level A is not exceeded. The top sound level C is neithert exceeded. During measuring, ear protectors EAR were used.

In general, the working site meets work safety requirements under condition that workers should keep safety rules for working in noisy conditions.

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