THE ANNALS OF “DUNAREA DE JOS” UNIVERSITY OF GALATI
FASCICLE XIV MECHANICAL ENGINEERING, ISSN 1224-5615
2013

STUDY ON THE INFLUENCE OF ULTRASOUND FREQUENCY EMITTED BY A SONIC GENERATOR ON WATER PARAMETERS

Ph.D.Eng.Assistant Anca Serban
”Dunarea de Jos” University of Galati

ABSTRACT

The importance of ultrasound frequency radiated by the sonic generator in the evolution of water quality parameters and its variation according to the pressure level of input air are described in the paper. Also, the generator’s acoustical parameters methodology was determined based on the standard for noise emissions. Thus, the ultrasound frequency of the sonic generator can be chosen depending on the optimal values of water parameters.

KEYWORDS: ultrasound, frequency, sonic generator, water parameters

1. Introduction

The sonic generator induces into the water mass both an air jet and sound waves at a certain working frequency. The paper presents the analysis of the ultrasound frequency emitted by the sonic generator and its influence on the raw water mass, respectively on water characteristics.

2. The sonic generator operation

The working gas used for the generator’s function (fig.1) is the air from a compressor provided in the installation for the generator operation [1].

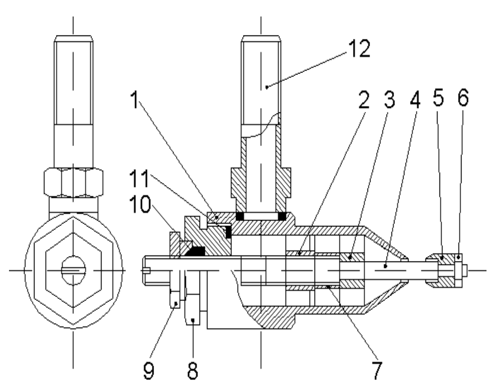

Figure 1. The sonic generator scheme: 1-air nozzle; 2,3-cross support; 4-rod; 5-resonator; 6-screw-nut M2,5; 7-sleeve; 8-cover; 9-locking nut; 10-gasket; 11- ring; 12-fitting.

Thus the air evacuates the generator via the nozzle slot, encounters the resonator 5 and enters the resonator slot, then leaves the resonator slot and returns, encountering the nozzle.
A part of the air that encounters the nozzle is dispersed into the environment and other part encounters again the resonator slot [2]. Encountering the metallic part of the nozzle or of the resonator, the working air generates vibrations.
This route of the air determined the frequency of the sonic jet [3] emitted by the generator to depend on the nozzle slot dimension, the resonator adjusting distance and the resonator slot dimension.
The sonic generator produces both air jet and sound waves [2] in the working range of the air pressure: $p=0,1\div0,4$ MPa.

3. The acoustic measurements of the sonic generator

The acoustic parameters of the sonic generator were achieved with the device „Brüel & Kjær”, a type of analyzer Agilent 35670A (fig.2) which effectuates the spectral analysis of frequency in narrow band (1/12 octave).
The noise was received by a prepolarized microphone type 4189 (fig.3) with free range ½” and the following characteristics [4]:
- the frequency lower limit of $2\div4$Hz;

Figure 2. The dynamic signal analyzer Agilent 35670A

- the membrane resonance frequency is 14 kHz;
- the maximum level of sound pressure L=158 dB;
- the superior limit of dynamic range >146 dB SPL (superior pressure limit)
- dimensions: 13,2 mm diameter and 17,6 mm height.

The microphone also contains a pistonphone type 4228 for correction.

Figure 3. The microphone type 4189

The equipment for an exact determination of the sound pressure level in the range of L=90÷130 dB and working frequency with a frequency range of ν =122μ Hz ÷ 102,4 kHz.

The calibration of the measuring system is achieved with the sound calibrator type 4231, which has the following characteristics [4]:

- frequency of ν=1000 Hz;
- sound pressure level L=94 dB or L=114 dB, with ±0,2dB error;
- distortion <1%.

The acoustical measurements were performed according to the fundamental Standard on noise emissions [5], at the measuring distance of one meter (fig.4).

The testing was made inside a large enclosure (50x30x10 m), which had the constant value K_{2A}, defined as in Annex A of Standard of ≥ 2,0 dB, that corresponds to measurements in open-air.

The microphone is posted on a turnover base (fig.4) and is placed in a horizontal plane, normal to the generator axis on a distance of one meter, so that the microphone axis passes through the center of the generator’s working area.

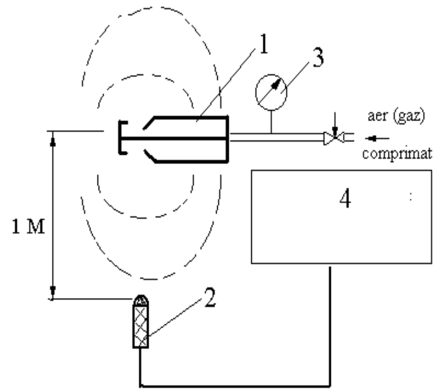

Figure 4. The acoustic testing diagram: 1- sonic generator, 2-microphone, 3-manometer, 4-testing system „Brüel & Kjær”

The backround noise durring the measurements did not exceed the level of 48 dB, which is much lower than the sound intensity produced by the sonic generator [4].

Furthermore, it was studied the influence of input pressure *p* on the acoustic frequency υ (table1) of the sonic generator.

Thus, in the range of pressure considered p=0,1÷0,4 MPa, the frequency increases in the field υ=23,2÷27,4 kHz, then it has a minor decrease (fig.5).

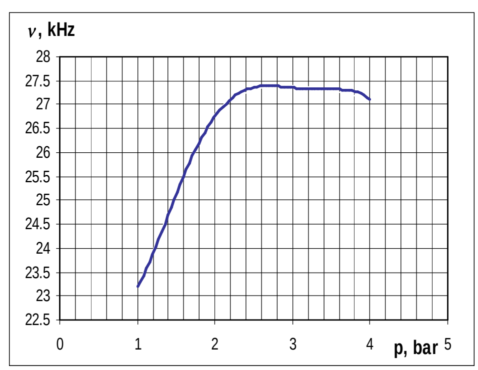

Figure 5. The variation of sonic generator acoustic frequency with the input pressure

Table 1.The working pressure and frequency

No.	Input air pressure, p, [MPa]	Ultrasound frequency, ν, [kHz]
1.	0,1	23,2
2.	0,15	25,1
3.	0,2	26,8
4.	0,25	27,3
5.	0,3	27,4
6.	0,35	27,3
7.	0,4	27,1

This result shows that the frequency υ=27,4 kHz corresponding to p=0,3 MPa is a critical value, after which the frequency has a insignificant variation [4]. Also, the result points out the ultrasonic character of the sonic generator frequency for the values exceeding the ultrasound inferior limit of 20 kHz.

4. The ultrasound frequency impact on the water indicators

The study analysed the influence of the sonic generator ultrasound frequency used for water treatment on the following water indicators: turbidity, pH, dissolved oxygen and nitrate. The technological conditions consisted in the input pressure p=0,1÷0,4 MPa, treating time t=30 seconds at the water temperature of 16^0C [4].

The evolution of water turbidity (fig.6) with the ultrasound frequency shows an important decrease and the optimal value is registred at the critical frequency υ=27,4 kHz.

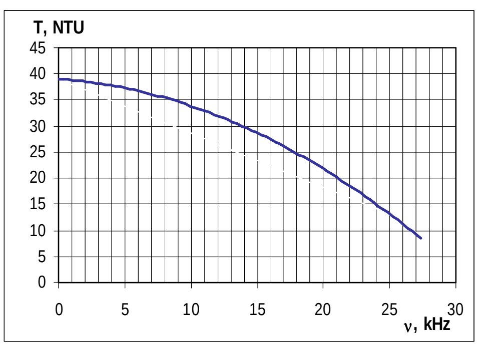

Figure 6. The variation of turbidity with the ultrasound frequency

In case of pH variation (fig.7), the values are situated within the standard range of pH=6,5÷8,5 [6], with the minimum value at the same critical frequency υ=27,4 kHz.

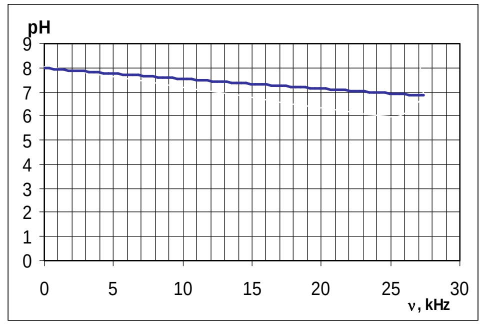

Figure 5. The variation of pH with the ultrasound frequncy

However, regarding the pH, the values obtained within the range υ=23,2÷27,4 kHz show the ultrasound with the relative frequency has a positive impact by adjusting the water pH at the optimal value.

The content of dissolved oxygen (fig.8) is also adjusted by the presence of ultrasound at the given frequency range υ=23,2÷27,4 kHz.

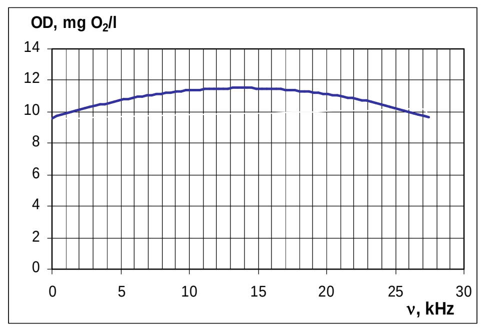

Figure 8. The variation of dissolved oxygen with the ultrasound frequency

At the critical frequency, the dissolved oxygen value returns to the initial value of the raw water. In contrast with the other indicators, the content of nitrate (fig.9) increases with the ultrasound frequency, which is not preferable as nitrate is dangerous both for public health and aquatic life.

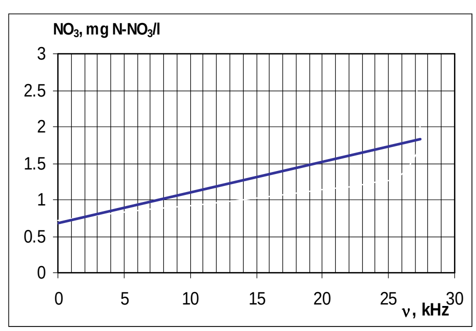

Figure 9. The variation of nitrate content with the ultrasound frequency

Thus, the ultrasound frequency emitted by the sonic generator connected to the input air pressure of the sonic generator determines the evolution of the water indicators analysed.
The results allow us to choose the acoustic frequency and the air pressure which lead to obtaining the optimal values of the water quality parameters.

5. Conclusions

The paper contains the operating mode, respectively the propagation modality of the sound waves emitted by the sonic generator.
The sonic generator function is based on a source of compressed air. Thus, the supersonic air jet from the nozzle, after interaction with the cavity resonator loses stability and delivers high-frequency shock waves.
The variation of pressure in the range of p=0,1÷0,4 MPa determined the acoustic waves emitted by the generator in the frequency field υ=23,2÷27,4 kHz. This frequency range belongs to the low frequency ultrasound (20-70 kHz).
The characteristic pressure-frequency obtained under standard conditions [5] has the critical frequency υ=27,4 kHz from which the frequency has an insignificant evolution.
The ultrasound waves in the specific frequency range determined a major decrease of turbidity and the lower value was obtained at the critical frequency υ=27,4 kHz.
The pH decreases by one unit under the influence of ultrasound frequency, but the main aspect is that the water pH registers standard values [6] in the entire frequency range.
The dissolved oxygen is slightly influenced by the ultrasound in the frequency field and the critical frequency determined the return to the value of the raw water.
In case of nitrate content, the increase by aproximatively 2mg NO_3/l, under the impact of ultrasound within the frequency field, is a negative result for the content of nitrate in water and it is a danger for people and aquatic life.
Thus, the results above lead to a general conclusion that the presence of ultrasound at the critical frequency υ=27,4 kHz and input air pressure p=0,3 MPa determine the optimal values for the water indicators analysed.

References

[1]. **BĂLAN, G.**, *Aerogazodinamică, Ed. Tehnica-Info, Chişinău, 2003.*

[2]. **BĂLAN G, ŞTEFAN A.**, *Shock Waves Physics Generated By Supersonic Semibounded Gas Jets*, 11 th International Conference "Man In The Knowledge Based Organization ", Sibiu 23-25 Nov., „Nicolae Balcescu " Land Forces Academy, Conference Proceedings VII, Land Forces Acad. Publishing House, Sibiu, 2006, ISBN 973-7809-51-3, 78-973-7809-516-3, pp. 44-51.

[3]. **BĂLAN G., CIUREA A., BĂLAN V., BORDEI M.,** *The sonic technologies,* Quatrieme Edition du Colloque Francophone en Energie, Environnment, Economie et Thermodynamique COFRET'08, Nantes, France, 2008, pp.20-29.

[4]. **ŞERBAN A.**, *Utilizarea generatoarelor sonice gazodinamice în procesele tehnologice de epurare a apelor uzate,* Editura Zigotto, Galaţi, 2012, ISBN 978-606-8303-57-4.

[5]. **SÂRBU M. A., POENARU D., DICU S., CIODARU M., STAN M.,** *Standardizarea acustică în România în anul 1997,* Academia Română, Comisia de Acustică, Bucureşti, România, 14-15 oct. 1997, Caietul 27, pp. 7-12.

[6]. O.M. 161/2006 pentru aprobarea Normativului privind clasificarea calităţii apelor de suprafaţă în vederea stabilirii stării ecologice a corpurilor de apă.