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ACOUSTIC AND PARAMETRIC STUDIES OF THE EXPERIMENTAL RADIAL SONIC GENERATOR

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ABSTRACT

In this paper the parameters of the acoustic field were studied experimentally,along with the frequency produced by the generator and the circular diagram of the generator’s acoustic emission, the influence of the nozzle’s slot size and the operating pressure of the generator (supply air pressure) on the parameters of the acoustic field produced by the generator .

KEYWORDS: generator, sonic, acoustic, resonator.

1. Introduction

In this paper the level of the acoustic intensity and the frequency produced by the generator were measured but also the parameters of the acoustic field produced by the generator, the influence of the slot’s nozzle size and that of the generator’s operating pressure.

The parameters of the acoustic field produced by the gasodynamic sonic radial generator were determined experimentally.

2. Construction of experimental sonic generator

Based on studies, the gasodynamic sonic radial system was designed.

The designed gasodynamic radial generator (Fig. 2) has the following main geometrical parameters:

- the nozzle’s slot δ= 0.1 ÷ 3 mm (adjustable);
- the resonator’s slot *Dr* = 2.0 mm;
- the diameter of the nozzle *Yes* = 44.0 mm;
- the distance between the nozzle and the radial resonator Δ_R= 1.5 mm.

With the lock ring generator it is attached to the gas injector.

The compressed air enters the gasodynamic radial generator through nozzle 5, coming out through the slot formed by resonator 1 and nozzle 2.

The air loses its stability and radiates high frequency waves (16 ÷ 20 kHz) due to the cavity formed by the resonator and the nozzle [1].

Between the parts (nozzle and resonator) to be able to adjust the format interstitium they were assembled through very fine threads.

The adjustment of the resonator 1 (Fig. 1,2) is performed by rotating part 2 which changes the gap between the nozzle and the radial resonator 1. The position of parts 1 and 2 is fixed with locknut 4 which in its turn is blocked with retainer 3.

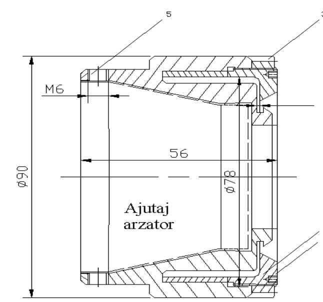

Figure. 1. Experimental gasodynamic radial sonic generator: 1 - resonator, 2 - nozzle, 3 - nut, 4 - connection hose; 5 - air supply pipe work

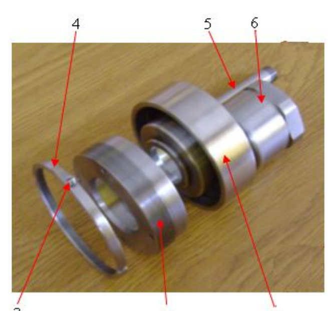

Figure. 2. Photo experimental gasodynamic radial sonic generator: Photo of the overall radial type generator gazodinamic: 1 - resonator; 2 - radial nozzle, 3 - pin fastening, 4 - nozzle retaining nut, 5 - air supply pipe work

3. The apparatus and the acoustic measurement method

The level of acoustic intensity characterizing the acoustic power is a main parameter produced by a source which in its turn is determined experimentally [1]:

$$L = 10\lg\frac{I}{I_0} \quad [\text{dB}] \qquad (2.1)$$

where: I[W/m2] - measured sound intensity (produced by the generator);

I_0 = 10-12 [W/m2] - threshold sound intensity.

Comparative data are obtained through experimental measurement of frequency and sound pressure waves produced by the generator:

$$L = 20\lg\frac{P_I}{P_0} = 10\lg\frac{I}{I_0} \quad [\text{dB}] \qquad (2.2)$$

where: PI [Pa] - measured sound pressure (produced by the generator);

P_0= 2.10 -5 [Pa] - threshold sound pressure.

Acoustic power can be determined by the formulas [2]:

$$W = 2\left(I_0 \cdot 2\pi r^2 \int_0^{\pi} 10^{\frac{L_\theta}{10}} \sin\theta \cdot d\theta\right) \quad [\text{W}] \qquad (2.3)$$

or

$$W = I_0 \cdot 4\pi r^2 \cdot 10^{\frac{L}{10}} \int_0^{\pi} \sin\theta \cdot d\theta \quad [\text{W}] \qquad (2.4)$$

where:

$L\theta$ [DB] - level of acoustic intensity, determined under the θ angle *from* the axis of the generator;

L [DB] - level of sound intensity determined in the normal direction to the axis of the generator;

θ [rad] - angle of circular diagram of emission;

r = 1m- standard radius of the measuring sphere corresponding to the distant undulatory field:

$$r \gg \frac{D^2}{\lambda} \qquad (3.5)$$

D- characteristic diameter of the transmitter [m];

λ - emission wavelength [m].

Depending on the changes in major operating parameters, noise measurements analyzed acoustic behavior of gasodynamic experimental radial generator.

Research has been conducted on the premises of SC FEROSTIL S.A. In parallel, noise research was conducted, with a single-chain of measurement shown in fig. 3.1.

The measurements were made by recording temporally the acoustic signal on a laptop (Fig.3) with the 0.1 dB Solo sonometer, which allows reading the levels of acoustic intensity in dB across the frequency spectrum.

For each measurement the corresponding spectrogram is attached.

In accordance with the standard of noise emission SR EN ISO 3744/2009 acoustic measurements were taken and by using sound pressure the acoustic power levels of noise sources were determined (Fig. 3).

Using the standard SR EN ISO 3744/2009, in accordance with Appendix A, the measurements took place at the headquarters of SC FEROSTIL S.A. in open space where the constant K2A was determined, which is larger than 2,0 dB, in which case the environmental correction K2A should not be taken into account, that corresponds to the outdoors measurements.

Fig. 3. Sonometer Solo 0.1 dB with laptop during measurements

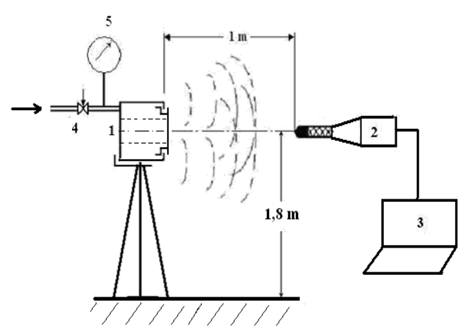

Fig. 4. Acoustic performance measurement scheme:
1 - radial acoustic generator, 2 - 0.1dB Solo sound level meter, 3 - laptop, 4-check stop valve, 5- gauge for the control of the generator’s working pressure

Measurements were made at a distance of 1m, so that the axis microphone 2 passes through the center of the generator’s work area (Fig. 4.) located at a height of 1.8 m.

During the research the background noise of the room did not exceed the level of (28.5 to 30.1) dB, which is much lower than the intensity of sound produced by sonic generator [2].
Measurements were performed in the acoustic intensity and frequency of sound waves produced by the generator.
To determine the generator's circular diagram of acoustic emission, measurements were performed to establish the acoustic parameters in front of the generator [3] by moving the sound meter on radius of 1 meter in the angles θ= 0 ÷ 1800 (the angle θ= 900 corresponds to the axial direction of the microphone in fig.3).
Working parameters according to which the generator was investigated are:
- generator operating pressure range (*p*= 0.05, 0.10, 0.15, 0.20, 0.25 MPa)
- slot nozzle has two dimensions: δ= 0.25 mm and δ= 0.50 mm
The circular emission of the acoustic field produced by the radial generator was investigated experimentally and the acoustic intensity and frequency [4] produced by the generator were determined .

4. Experimental research on acoustic circular emission of the radial asodynamic generator the construction of the sonic generator

Emission research was carried out at constant pressure p = 0.2 MPa generator with slot δ= 0.50 mm in the horizontal plane passing through the axis of symmetry of the generator and measuring angles being in the θ = 0º -180º (fig. 6).

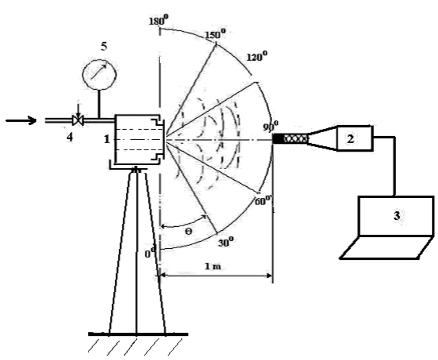

Fig. 6. Pattern of performing measurements at different angles of the generator's acoustic emission: 1 - radial generator, 2 - sound meter, 3 - laptop, θ - measurement angle

In fig. 5 the spectrum of the experimental radial generator's acoustic emission is presented.

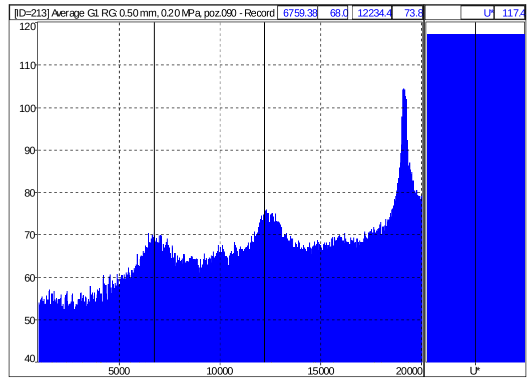

Fig. 5. Pulsation spectrum at working pressure *p*= 0.20 MPa, δ = 0.50 mm, the angle of emission θ = 90 °.

The study variation of acoustic emission spectrum of radial generator based on supply pressure showed that the intensity acoustic pressure p (p = 0.05 ÷ 0.30 MPa) increased from 89.90 MPa to 107.90 dB dB, a difference of 18 dB, which corresponds to increasing noise intensity I/I0 about 14 times and sound pressure P/P0 5 times.In table 1 the measured numerical values are shown.
The overall level of intensity $L\theta$ (table 1) results from the taken measurements and it varies according to the direction of the microphone from 103.9 dB to 117.4 dB and the resulted difference of 13.5 dB corresponds to approximately 4 times the acoustic intensity variation .
Frequency has values between 19.00 kHz and 19.21 kHz, so basically frequency does not change.
At the same time, at two angles within the 90 ÷ 120º angles' range, the second frequency in the 12.23 kHz range with the acoustic intensity of 76 dB is observed.

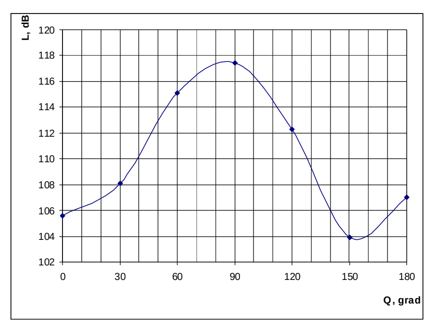

Fig. 7. The level of acoustic intensity L depending on the angle of emission θ of the gasodynamic radial generator (working pressure *p* = 0.20 MPa, slot nozzle δ = 0.50 mm)

Tab 1. The acoustic parameters depending on the radial experimental generator’s angle of emission θ

θ angle	0^0	30^0	60^0	90^0	120^0	150^0	180^0
Global level, L_θ, dB	105.6	108.1	115.1	117.4	112.3	103.9	107.0
The first frequency f_I,, KHz	19.05	19.00	19.09	19.21	19.18	19.05	-
The second frequency f_{II},, KHz	-	-	-	12.23 *	12.23 *	-	-

The third frequency is due to the noise produced by the compressor appropriate to the compressor’s speed. Polynomial approximation of acoustic intensity level L depending on the angle θ emission radial gazodinamic generator using MathCAD PLUS is:

$$y = 4\cdot10^{-7} \cdot x^4 - 10^{-4}x^3 + 0{,}0125x^2 – 0{,}1879x + 105{,}65$$
$$R^2 = 0{,}9986$$

where:

$x = \theta^0$; $y=L$,dB; R^2 - the standard deviation (error of approximation).

The variation of acoustic intensity L presented in 9 (fig. 7) shows that the maximum of emission occurs in the normal direction on the front surface of the radial generator (θ =90º).

The feature of the total acoustic intensity variation changes depending on the angle of emission, the curve L can not be considered punctuate, but it is a cross quadripole, that is a complex source consisting of two dipoles that pulse in perpendicular directions [2].

The obtained results from acoustic measurements indicate that the radial jet pulsates the least in the flow directions, the radial and transversal one, forming two sources of acoustic emission.

5. Conclusions

Testing technology of gasodynamic radial ultrasonic generator was designed and conducted on a gas injector of a combustion plant.

The parameters of the acoustic field produced by the gasodynamic radial sonic generator were determined experimentally.

The level of acoustic intensity and the frequency produced by the generator were measured. By moving the microphone on a distance of 1 meter in the angles δ= (0 ÷ 180)º in order to determine the pie chart of the generator’s acoustic emission the sound parameters situated in front of the generator were measured.

In what concerns the parameters of the acoustic field produced by the generator, the influence of the slot nozzle size δ= 0.25 to 0.50 mm and the generator’s operating pressure p= (0.05-0.20) MPa (Supply air pressure) were studied.

The overall level of intensity L_θ (table 1) results from the taken measurements and it varies accordong to the direction of the microphone from 103.9 dB to 117.4 dB and the resulted difference of 13.5 dB corresponds to approximately 4 times the acoustic intensity variation.

Frequency has values between 19.00 kHz and 19.21 kHz so basically frequency does not change. At the same time, at two angles within the 90 ÷ 120º angles’ range, the second frequency in the 12.23 kHz range with the acoustic intensity of 76 dB is observed.

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