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The possibility of increasing emission intensity of a counter-current hydrodynamic generator

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Abstract

The article considers the possibility of increasing operation efficiency of a counter-current hydrodynamic generator, used for the intensification of chemical technology processes. To increase the intensity of the emission it is suggested to use rod resonance system, where the frequency of bending vibrations is in agreement with the frequency of flow shell vibrations. The dependence of the frequency of the generated signal on geometric and hydrodynamic oscillator parameters is experimentally proven. It is also found out that the dependence of the pressure differential, produced by a resonator, on the liquid consumption, will look like a resonance curve. To keep maximum values of the generated vibrations amplitudes, it is suggested to use extremal system of the automated control.

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Keywords: counter-current hydrodynamic oscillator; submerged flow shell; emission intensity; vibrations major tone amplitude; resonance frequency; extremal control system

1. Introduction

With the purpose to intensify chemical technology processes and to increase the efficiency of the chemical technology equipment the approach, associated with creating various physicochemical artificial effects thanks to implementing internal or external sources energy, is widely used [1]. Advanced are considered the methods, based on the excitation vibrations sonic and ultrasonic band in the processed environment [2]. Such vibrations intensify the processes of emulsionizing, dispergating, solubilizing and so on, thanks to the occurring in this environment complex non-linear effects: cavitating; acoustic flows; bubbles oscillations; surface effects etc. Moreover, acoustic

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methods of the processing are several times better than others concerning the degree of mechanical processes intensification [1].

Using of resonance systems provides increasing of the generated vibrations intensity. However, efficient operation of these devices is possible in the narrow frequency band and is directly related to the supplied liquid consumption. What is more, the dependence of the pressure differential, created by a resonator, on the liquid consumption is of the form of a resonance curve.

In view of the above, the possibility of developing extremal system of automated work adjustment of the hydrodynamic counter-current generator in resonant mode seems to be up-to-date.

2. Study subject

One of the advanced wave generators is axisymmetric counter-current hydrodynamic oscillator (Fig. 1), providing generating a tone signal of high intensity in liquid.

Its operating principle is the transforming of kinetic energy of the liquid, flowing from nozzle 1, into acoustic waves energy in the process of the submerged flow impingement with deflector 3. According to [3], liquid, flowing with high rate from the nozzle, is formed into the submerged elastic flow conic shell 2 as a result of the contact with a deflector parabolic cavity. Pulsations of the primary vortex, appearing inside the flow shell, force the shell to make bending vibrations. As it is known [4], if we vary the flow rate under given oscillator geometric parameters, we can obtain matching the primary vortex pulsation frequency with natural frequency of the flow shell, which will provide maximum signal generating.

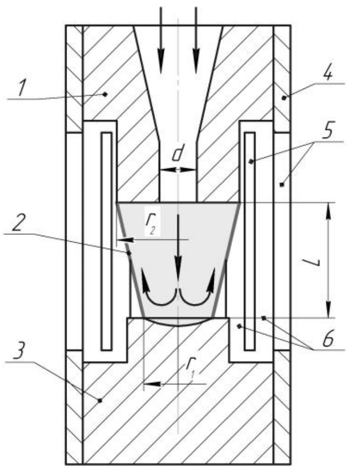

Fig. 1. Rod counter-current hydrodynamic oscillator: 1 – inlet nozzle; 2 – submerged flow shell; 3 – deflector; 4 – pump and compressor pipe (PCP); 5 – milled slots; 6 – resonant rods.

It seems possible, with the purpose of increasing the emission intensity much more, to use extra resonators. Structurally, resonators can have a form of rods 6, obtained by long slots 5 in a thin-wall pipe body. It is obvious, that rod and flow shell frequencies should be in accordance.

The formula for circular frequency of the basic form vibrations for a submerged flow shell, obtained in [3], let us find the fundamental harmonics frequency depending on the geometric and hydrodynamic parameters:

$$f_0 = \frac{1}{2\pi} \cdot \sqrt{\frac{E_0 \cdot (k_0{}^2 \cdot h^2 \cdot r^2 + 12)}{12 \cdot r^2 \cdot \rho_0}} \tag{1}$$