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Controlling hydrodynamic generator emission intensity at the edge tone frequency

Kapelyuhovskiy A. A.[a,*], Buryan Yu. A.[a], Kapelyuhovskaya A. A.[a]

[a]*Omsk State Technical University, 11, Mira Pr., Omsk, 644050, Russian Federation*

Abstract

The paper considers the possibility of increasing the efficiency of flow hydrodynamic elastic waves generator being used to intensify chemical and physical processes. To increase the emission intensity at the edge tone frequency, it is suggested to use Helmholtz resonator. The possibility to control pressure differential created by a resonator as a result of the liquid flow velocity at the ring-spray nozzle of the flow generator is experimentally confirmed. For maintaining maximum amplitude values of the genevelocityd oscillations, the coalescence of the edge tone frequency with Helmholtz resonator frequency is necessary. With this purpose, extremal automatic control system is suggested.

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Keywords: hydrodynamic generator; Helmholtz resonator; flow generator; edge tone; resonance frequency; extremal control system.

1. Introduction

In order to increase the efficiency of chemical engineering equipment and the intensification of chemical and technological processes various methods based on the introduction of third-party sources of energy the process are used [1]. Among acoustic processing devices used in industry to influence the fluids, hydrodynamic sources of acoustic vibrations are considered the most effective [2]. The main advantage of these emitters is design and operation simplicity, the lack of high-voltage equipment, and their low cost. Acoustic oscillations occur due to the working fluid flow energy, which does not require the development of special energy-transfer systems.

There are many different designs of hydrodynamic generators with a particular physical effect and used in petrochemical, food processing, pulp and paper, mining and other industries.

* Corresponding author. Tel.: +7-908-107-3841.
E-mail address: vesto4ka@bk.ru

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To increase the power of the generated signal, different resonance systems, such as Helmholtz resonator, are used [3]. The efficiency of these systems is related to the accuracy of matching the frequency of the hydrodynamic pulsations with the frequency of the resonant system.

In view of the above, the opportunity to create an automatic control system that provides coincidence between hydrodynamic generator and Helmholtz resonator frequencies, due to the fluid flow change is up-to-date.

2. Study subject

Generator, creating periodic pressure differential in the throat of Helmholtz resonator, is a device with a ring slit (nozzle) through which the processed fluid, supplied by a pump, flows at high velocity onto a coaxial wedge (Fig.1).

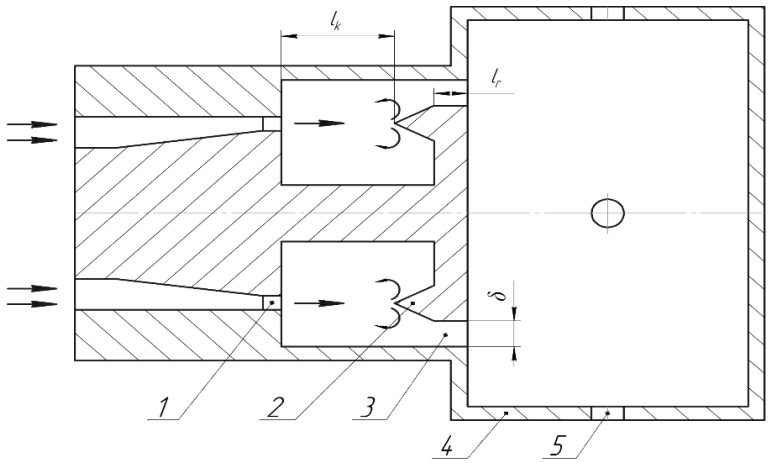

Fig.1. Hydrodynamic generator diagram:

1 - ring slit (nozzle); 2 - wedge; 3 - Helmholtz resonator throat; 4 - Helmholtz resonator; 5 – fluid outflow openings.

Unsteady primary turbulence in the submerged flow occurring during the leakage to the wedge create waves that, upon reaching the mouth of the flow, under certain phase ratios, define stable self-oscillations with the edge tone frequency [4]. To enhance the self-oscillations, it is suggested to use a Helmholtz resonator, because some designs of hydrodynamic generators on a similar basis are known.

3. Methods

To determine the frequency of the edge tone of the system “nozzle mouth - unsteady working fluid flow – wedge”, empirical dependence [5], which gives a good agreement with the experimental results, was used:

$$f_i = \frac{i \cdot k \cdot V}{4 \cdot l_k} \tag{1}$$

where i = 1, 2, 3 ...,
V is average cross-section speed of the flow at the nozzle outlet,
k = 0.765 – 0.770 is empirical constant,
l_k is distance from the mouth of the flow to the wedge.