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Characteristics and Calculation of Cavitation Mixers

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Abstract

It is shown that one of the most efficient ways to obtain emulsion is cavitation treatment of the mixed stream in the jet boundary layer. The authors offer a model for calculating the operational process in the hydrodynamic mixer with multiple-jet nozzle as agitator of cavitation, based on hydrodynamic equations and data of experimental research on jet pumps. There has been considered and analyzed the characteristic of the cavitation mixer, which shows how relative loss of total stream pressure depends on relative nozzle square, and hydraulic resistance coefficient of flow-part elements. It is shown that gradual reduction of hydraulic resistance coefficient allows to decrease considerably the loss of total stream pressure. Besides, there exists the range of optimal relative square values where losses of total pressure are minimized. If the elements of the mixer flow-part are made hydraulically proper then the optimal values of the nozzle relative square are 0,66…0,76, whereas minimum losses of relative pressure don't exceed 0,22.

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Keywords:

1. Introduction

An urgent task of machine building, power engineering, chemical, oil and food manufacturing industries is to develop efficient and low-power mixer to prepare emulsions. For instance, in heat-power engineering burnout of diesel oil emulsion in steam boiler furnace units allows to reduce toxicity of stack gases, and if there is an optimum choice of parameters of fuel burnout and preparation of diesel oil emulsion, environmental and technical-and-economic indexes of boilers will be increased [1]. However, application of high capacity mixers helps to prevent disposal of wastewater contaminated by petroleum products into environment.

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The quality of emulsion is characterized by structure homogeneity and dispersion degree of components. Consequently, operational efficiency of mixers, i.e. devices for emulsion preparation, significantly depends on the preparation method. Creation of highly-dispersive emulsion by means of traditional mechanical stimulation of flow components is rather complicated. Cavitation treatment of mix elements, which generates local energy concentration (pulsations and cavitation bubble collapse) enough for diffusion of medium components on the micro level, allows to obtain highly-dispersive product resistant to breaking. [2]. Literature review devoted to cavitation in jet pumps has shown that one of the most efficient ways to create emulsion is cavitation in the jet boundary layer [3]. At the same time to increase emulsion dispersion degree it is necessary to equally distribute cavitation points along the standard cross-section of the flow, and to enlarge their number when possible. One of such devices – agitators of cavitation is a multiple-jet nozzle with equally spaced holes which form several high velocity jets in a flow-part of a mixer.

The goal of this research is to perform calculation and analysis of characteristics of the jet cavitation mixer.

2. The schematic diagram and calculation model, characteristics of the hydrodynamic mixer

The schematic diagram of the jet mixer is shown in Figure 1. The mixer consists of a nozzle (1), the mixing chamber (2), and diffuser (3). The acceleration of a mixed stream and its dispersion into high-speed jets takes place in a multi-jet nozzle, where further in the jets' boundary layers cavitation is initiated. Cavitation treatment of the flow results in the breakdown of jets and formation of highly dispersed medium. Due to equal distribution of cavitation points along the standard cross-section of the flow at a certain distance from the nozzle (1) vapor-liquid turbulent flow is formed in the mixing chamber (2) which further turns into low flow in the condensation shock. As a result emulsion is created near the outlet section of the mixing chamber. In a diffuser the part of kinetic energy of emulsion flow transforms into potential one. The pressure thus increases to the value smaller than before the mixer.

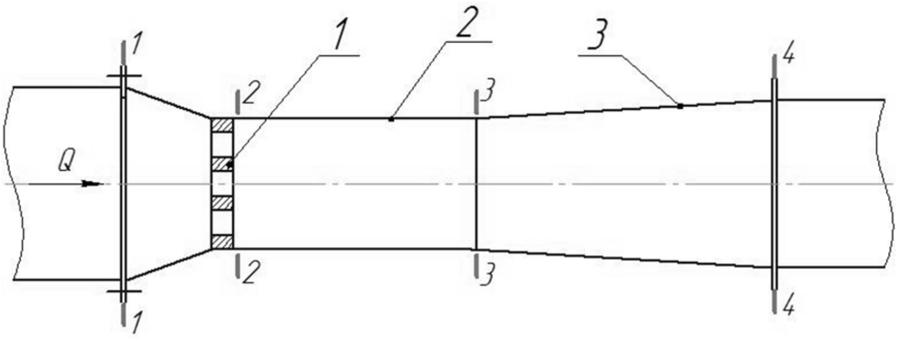

Fig.1. The schematic diagram of the hydrodynamic ejector.

Input equations which describe operational process in a mixer are the equations of balance of consumption:

$$Q = v_i A_i = const; \qquad (1)$$

and specific energy of flow in the area between sections 1-1 and 4-4:

$$\overline{p_1} = \overline{p_4} + \zeta_C \frac{\rho v_2^2}{2} + \frac{\rho v_3^2}{2}\left(\zeta_K + \zeta_Д\right) + \Delta \overline{p_P} \qquad (2)$$

Bernoulli equations for the mixed stream in the area between sections 1-1 and 2-2: