Effect of Cavitation Processing on Nitrogen Dissolution in Sunflower Oil

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Abstract* – *Work is devoted to the research of the influence of cavitational treatment on the process of nitrogen dissolution in sunflower oil. The team researched the possibility of using of low-frequency vibrocavitational device for the increase of concentration of dissolved nitrogen.

Keywords – intensification, cavitation, bubble, vibro-resonance, Venturi tube, pressure, concentration.

Introduction

At present time, for the intensification of technological processes in the developed countries of the world, the theory of discrete-pulse energy input (DPEI) is widely used in the technological environment. The general principles of DPEI, energy and thermodynamic aspects, as well as the main mechanisms of intensification of technological processes are detailed in many literature sources. DPEI mechanisms can be conditionally divided into "hard" and "soft". Hard modes are recommended for the intensification of hydromechanical processes, and soft modes are recommended for the intensive mixing of multicomponent media. In practice, such conditions are achieved by the ultrasonic impact on the liquid or by creating special hydrodynamic conditions in cavitation devices, in particular in the Venturi tube.

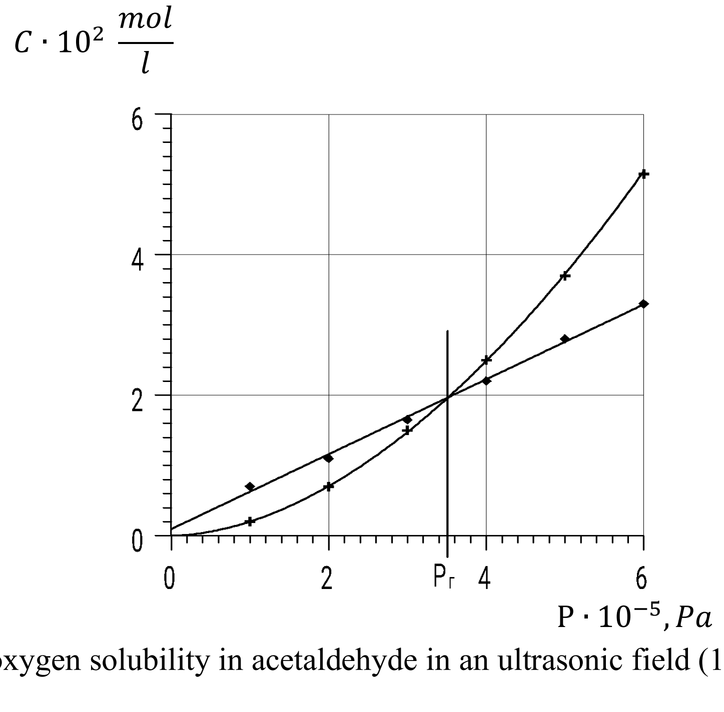

Fig. 1. Dependence of oxygen solubility in acetaldehyde in an ultrasonic field (1) and without it (2).

As is known [2], during gas bubbling in a liquid in an ultrasonic field at low pressures, a decrease in dissolved gas concentration is observed, it is lower than according to Henry's law, and at high pressures – acoustic aeration (Fig. 1), where the solubility of gases is higher.

Analysis of literature sources showed that such conditions can be achieved by hydromechanical cavitation [1] or by using low-frequency vibroresonance cavitators [2, 3].

For the aeration of sunflower oil with nitrogen, it is proposed to use a Venturi tube, which can be easily installed in the existing technological equipment for bottling of sunflower oil. The use of Venturi tubes depends on their type, the cross-section profile of the inlet cone, and the relative diameter of the neck β (the ratio of the diameter d of the neck to the inner diameter D).

It is known that the movement of liquid is disturbed due to the formation of cavities filled with gas and steam due to a local decrease in the level of liquid pressure. During the outflow of liquid, if the flow is throttled with a significant pressure drop, hydrodynamic cavitation occurs as a result of an increase in the speed of liquid movement.

The diagram of the proposed version of the Venturi tube is shown in Fig. 2.

Volume flow rate of liquid is determined based on:

$$Q = \frac{C \cdot A_2}{\sqrt{1-\left(\frac{A_2}{A_1}\right)^2}} \cdot \sqrt{2 \cdot \frac{P_1 - P_2}{\rho}},$$

where C is the experimental coefficient reflecting the losses inside the Venturi tube; A_1 and A_2 – cross-sectional area of pipeline and neck, respectively; ρ – liquid density; $P_1 - P_2$ – static pressures at the entrance to the pipe and in the neck.

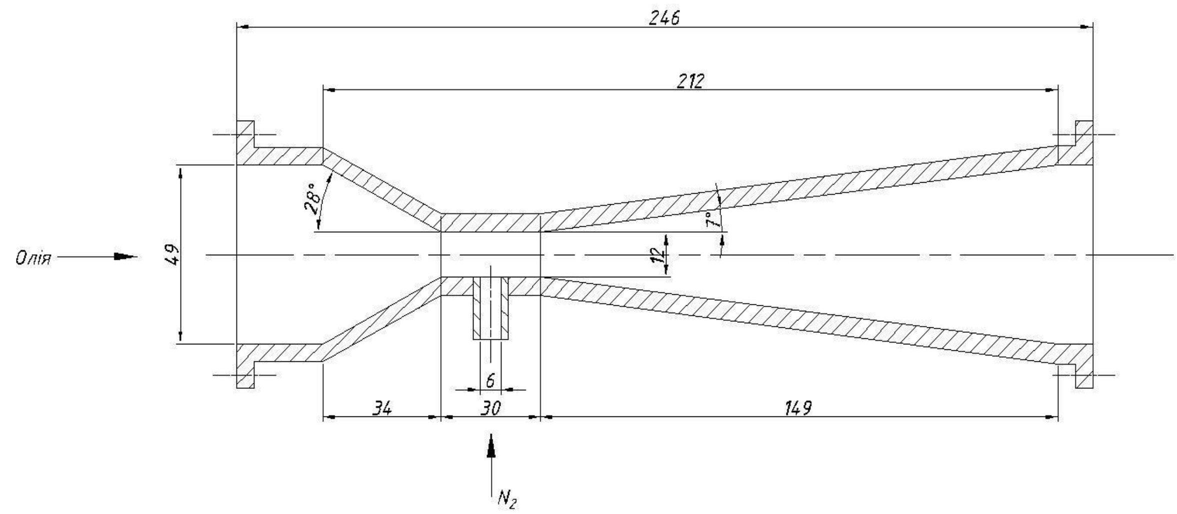

Fig. 2. Calculation scheme of the Venturi tube

The results of the calculation of the Venturi tube are shown in the table. 1.

Since vibro-turbulent flows are formed in the Venturi tube at the exit, in which cavitation occurs, experiments were also conducted on the effect of cavitation on the dissolution of nitrogen in oil in a low-frequency vibroresonance cavitator.

A low-frequency vibro-resonant cavitator [3] (Fig. 3) was used for the experiments with a frequency of oscillations of the cavitation dec-disturbers from 5 to 100 Hz. Frequencies of 37, 50, and 72 Hz were used, at a temperature of 20°C, a pressure of 1 atm, a nitrogen flow rate of 1 ml/s, and a sunflower oil processing time of 1-2 minutes.

Table. 1

The main calculation parameters of the Venturi tube

Pipe at the entrance, exit						Narrowing of the Venturi tube			
Pressure	Productivity by oil		Diameter $d\times10^2$	Area $F\times10^3$	Speed v	$d_1\times10^3$	$F_1\times10^5$	Speed	Reynolds number
Pa	m^3/hr	m^3/s	m	m^2	m/s	m	m^2	v_1, m/s	$Re\times10^{-6}$
196200	4	0,001	4,9	1,88	0,59	6	2,8	39,32	3,6
						8	5,0	22,12	2,7
						10	7,85	14,15	2,2
						12	11,3	9,83	1,8

Fig. 3. Photo of a low-frequency vibro-resonance cavitator with a control panel for controlling the frequencies of oscillations of deck-cavitation disruptors.

At all frequencies, an acceleration of the dissolution of nitrogen in the oil is observed in a few seconds, and this was visible to the naked eye. The time for complete degassing of nitrogen in the stoppered bottle was 15-20 min, depending on the frequency of oscillations of the dec-disturbers. The best filling (dissolution) of nitrogen was observed at a frequency of 50 Hz.

Thus, in order to achieve the goal of increasing the concentration of dissolved nitrogen in the oil and reducing the size of gas bubbles smaller than 200 μm, it is advisable to use the cavitation method. It allows you to completely expel the air from the bottle during its filling before sealing it.

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