The Simulation of Cavitation Process Using the Engineering Analysis Methods

Roman Pidhirnyi[1], Anna Hlukhaniuk[1], Oleksandr Motrunich[1], Oleksandr Ivashchuk[1], Volodymyr Starchevskyy[2]

1. Department of Chemical Engineering, Lviv Polytechnic National University, UKRAINE, Lviv, S. Bandery street 12, E-mail: oleksandr.s.ivashchuk@lpnu.ua

2. Department of General Chemistry, Lviv Polytechnic National University, UKRAINE, Lviv, S. Bandery street 12, E-mail: vstarch@lp.edu.ua

Abstract – The expediency of analysis and evaluation of the cavitation process by methods on the CAE software complexes have been shown.

Keywords – CAE, engineering analysis, simulation, cavitation, SolidWorks.

I. Introduction

Cavitation is a process of formation of cavities in fluids filled with gas, vapor or a mixture of them (so-called cavitation bubbles or cavities) [1]. Cavitation bubbles are formed in those places where the liquid pressure reaches a certain critical value of P_{cr}. The sharp collapse of the generated gas cavities creates a very sharp sudden increase in local pressure creating rapid change in pressure and hydrodynamical properties of current volume [2]. In the order to a low amount of the engineering researches of this process, CAE investigation of the cavitation has been conducted.

II. Experimental part

For engineering modeling of the process, the series of experiments with a model mixture on a vibration cavitator (Fig. 2) were conducted. A model water solution of isopropyl alcohol with concetration $1,2\times10^{-3}$ mol/l. Series of indicative measurements of chemical oxygen demand were done to analyse amout of oxidizable pollutants. Analytical analysis was conducted due to recommendations [3].

The Dichromate Chemical Oxygen Demand (COD) test measures the oxygen equivalent of the amount of organic matter oxidizable by potassium dichromate in a 50% sulfuric acid solution. End products are carbon dioxide, water, and various states of the chromium ion. After the oxidation step is completed, the amount of dichromate consumed is determined titrimetrically or colorimetrically. Either the amount of reduced chromium (chromic ion), or the amount of unreacted dichromate, can be measured. If the latter method is chosen, the analyst must know the precise amount of dichromate added.

$$2\ K_2Cr_2O_7 + 8H_2SO_4 + 3C \rightarrow 2\ K_2\ SO_4 + 2\ Cr_2(SO_4)_3 +$$

$$+3\ CO_2\uparrow + 8H_2O\ [4]$$

Chemical oxygen demand results are usually expressed by the amount of oxygen consumed during the oxidation of organic matter. When oxygen is used as the primary oxidant in the oxidation of potassium acid phthalate, the equation above describes the reaction.

The results of the researches are shown in the Table 1 and Fig. 1.

TABLE 1

RESULT OF THE COD ANALYSIS.

Frequency, hz	30	35	40	45	50
O_2 demand, mg/ml	4,48	8,64	18,24	29,44	29,44
	10,88	13,44	24,64	31,04	32,64
	16	27,52	30,08	39,04	36,48
	21,12	32,64	35,84	39,04	40,64

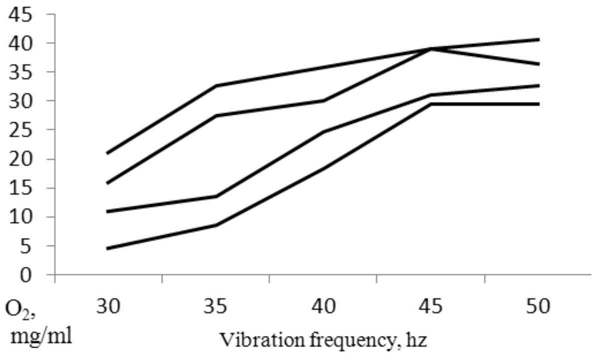

Fig. 1 The relation between COD frequency values.

III. Model of the laboratory device

For experimental investigations the compact laboratory electromagnetic vibration cavitator (Fig.2) has been used [4].

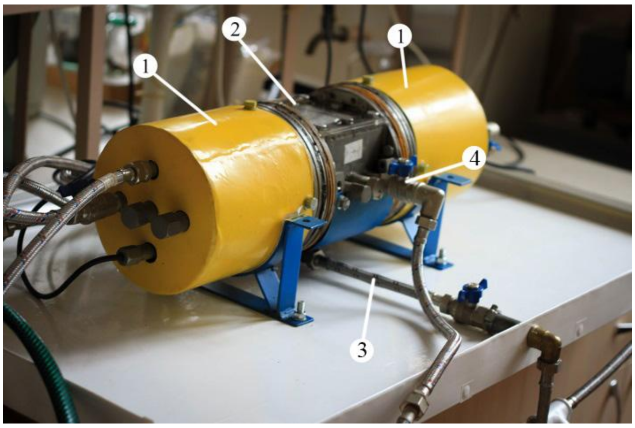

Fig.2 The laboratory electromagnetic vibration cavitator: 1 – electromagnetic vibration drives, 2 – operational chamber with three cavitation disks, 3 – liquid outlet , 4 – liquid inlet

Cavitation disks are moving in X-axis, creating distortion of the mixture wich follows the cavitation process.

For the analysis of hydrodynamics and cavitation process a solid model of the laboratory cavitator has been created in the CAD/CAE software complex of SolidWorks 2016 Educational Edition [5].

The solid model of the operational chamber with three cavitation disks is shown in the Fig. 2.

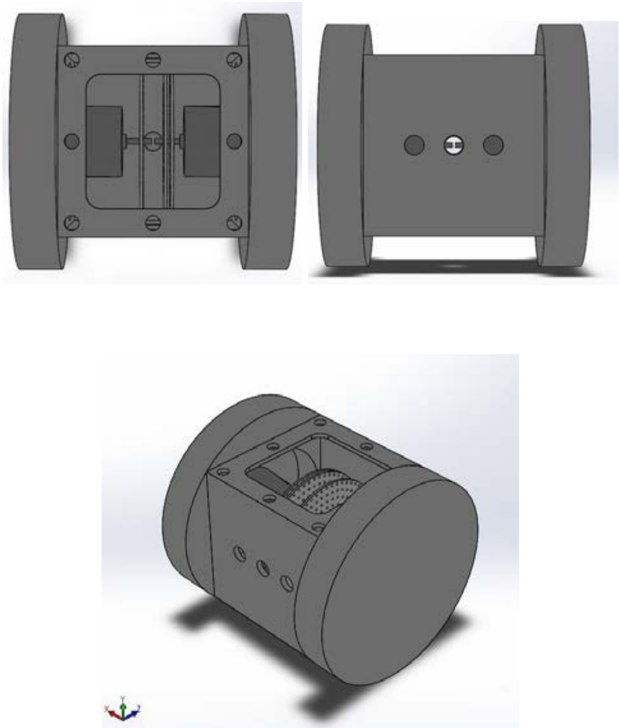

Fig.3 The solid model of the vibration cavitator created in SolidWorks 2016 Educational Edition.

Conclusions

The research results will be published. The results are going to show simulation of the cavitation process, which has a wide use in various industrial processes. That will help in the research of the practical process using.

Acknowledgment

The authors are expressing the gratitude to the company «Intersed-Ukraine», the official representative of SolidWorks Corp. in Ukraine.

References

[1] A. T. Ellis, “Cavitation in Hydrodynamics”, HMSO, Paper *8*, 1956.
[2] S.S. Martynov, D.J. Mason, M.R. Heikal “Numerical simulation of cavitation flows based on their hydrodynamic similarity”, 2005.
[3] Q. Yang, Z Liu. et al. “Simultaneous Determination of Chemical Oxygen Demand (COD) and Biological Oxygen Demand (BOD5) in Wastewater by Near-Infrared Spectrometry”, Journal of Water Resource and Protection, Vol. 1 No. 4, 2009.
[4] L.I. Shevchuk et al. “Nyzkochastotni vibrorezonansni kavitatory”, p. 176, 2013.
[5] Tickoo Sham, “Solidworks 2016 for Designers”. CADCIM Technologies, 2016.