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FOSARE SEMINAR SERIES 5

The Future of Food Safety Research in the European Union:

Building the European Research Area

Contaminants and influence of agricultural practices

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Registration and call for contributions

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Abstract or summary of benefits: ABSTRACT

Hydrodynamic cavitation causes damages over aparatos because of intensive cavitational erosion of the elements in the hydrosystem. Being acquainted with the mechanisms of effect, the hydrodynamic cavitation can be used to intensify technological processes in different industrial areas. The objective of the present work is experimental exploration of the possibility for microbiological water cleaning through processing in conditions of developed hydrodynamic cavitation. Here, we present the results of the conducted experimental studies. The initial trials confirm the idea of microbiological purification of nature and waste waters through having an immediate effect of hydrodynamic cavitation. They open wide opportunities for applying this method in various industrial fields.

Key words: cavitation, water purification, microbe number

INTENSIFICATION THE PROCESS OF WATER PURIFICATION BY HYDRODYNAMIC CAVITATION

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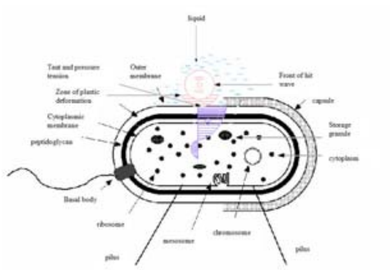
ABSTRACT
Hydrodynamic cavitation damages the apparatus by intensive cavitational erosion of the elements in a hydro system. Being acquainted with the mechanisms of effect, hydrodynamic cavitation can be used to intensify technological processes in different industrial areas. The objectives of the present work are experimental exploration of the possibilities for microbiological water purification through processing in conditions of developed hydrodynamic cavitation. To intensify the purifying process series of trials, at different levels of intensity of the electrical field in the zone of cavitation, are performed. Additionally presented, the electrical field assists in forcing the process of silver ions separation with the purpose of microbiological purification of the flowing water.
Here we present the results of experimental studies conducted at various cavitational numbers and electrical fields intensity. These trials substantiate the idea of the microbiological purification of nature and wastewaters via hydrodynamic cavitation and represent a huge range of opportunities for applying this method in various industrial fields. The basic criterion that supports our statement is the enormous drop of the microbe number by increasing the cavitation treatment time.
Key words: cavitation, water purification and microbe number

- **1. Introduction:**
- Cavitation is a method with effective use in destroying of complex organic chemicals, biorefraction materials, etc. Pulsation of pressure, speed alternation and temperature are results of the varying geometrical conditions in a cavitation area. [2]
- Cavitation has a dual effect: local and total. The local one reflects in accumulating ability of a separate cavitational cavern to release built-up energy of condensed type. The two major hypotheses that describe this phenomenon are the symmetric and non-symmetric collapse. Cavitational collapse is a symmetric spherical contraction of a cavern, which sometimes is followed by a hit wave, or a non-symmetric collapsing where contraction starts at one side and the contact wall is destroyed by the influence of the micro stream formed in the cavern. As regard to the total effect, it is a summed effect of the separate cavitation caverns. It spreads over a bigger surface and may cause its destruction. The local influence of cavitation brings cavitational destruction. In case of prolonged local treatment of the surface of the streamed object we observe mushroom-shaped destruction, which is a characteristic of cavitation. Microorganisms destroying, water and other liquids purification from microbiological contaminators is a result of the local effect of cavitation. For water the speed of the micro steam is about 100m/s; however, there are cases when it exceeds this value and reaches 550m/s at more high-pressure gradients. No living cell can resists a hydraulic impact with a speed of that range without its cell wall being torn.

- **2. Methods and Materials**
- A bacterium wall outlines the borders of a microbe body. It contacts the environment and has a thickness of 5÷30 nm. The bacteria wall is two-layer. Its internal layer consists of spherical macromolecules at a diameter of 12-14 nm. It is determined that between those macromolecules there are pores up to 1nm big. They could naturally hold non-dissolved gas that can be a basis of a cavitation core formation. [4].



- Fig.1 Mechanism of destruction the cell wall of a microbe body – diagrammatical picture
- Microorganisms resist high pressure and mechanic impacts. Many bacteria can withstand more than 100Pa pressure. Microorganisms' resistance varies in a wide range. When pressure is exercised over atmosphere of some gases like O2, CO2, etc., microorganisms become sensible and their life-resistance reduces remarkably [6, 7]. Supersonic waves have a strong influence, which at certain conditions, may lead to immediate cell destruction. Often the cell membrane is the most vulnerable part. Supersonic as a sequence of cavitation acts destructively toward all groups of microorganisms-mushrooms, bacteria, actinomicets and viruses.
- The objectives of the present work are exploration of the possibilities for utilizing hydrodynamic cavitation in purification of nature and surface waters. To intensify the process of purification, electrical field is created and the field has different intensity upon silver plates placed in the cavitation zone. The experimental studies are conducted on a stand where hydrodynamic cavitation is performed in the zone of a cavitator with especially projected protracted part. The diagram of the stand is on fig.2
- Before each trial starts, we take a 10ml control water probe from the reservoir (non-cavitated water). It is the base to compare the probes of the cavitated water during the different time intervals. Vacuum followed by overpressure reacts as effectively as high-pressure the stream is. Microorganism destruction by cavitation with damage of their cell membrane is based on application of that high-impact effect. [4, 5]

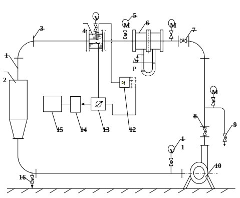
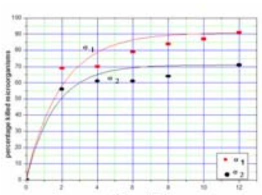


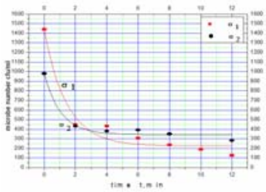
fig.2. Scheme of laboratory installation

1 – tubing system;
2 – reservoir;
3 – flange;
4 – cavitator;
5 – pressure gauge;
6 – blind;
7 – control valve;
8 – injection valve;
9 – release valve;
10 – centrifugal pump;
11 - vacuum gauge;
12 – reetifier;
13 – digital multimeter;
14 – computer;
15 – monitor;
16– valve to take tests

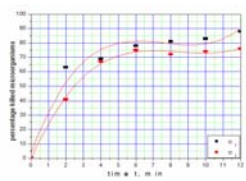
- The cavern that closes possesses a big volume of cumulative energy. The place of hitting the cavern onto the wall of the streamed object (vessel) or against the microbe cell is charged with high pressure. Upon the surface of the cell wall we provoke hydraulic impact by alternation of vacuum and high pressure that attends the closing of a cavitation cavern. The high speed of the stream performed at the cavern destruction is the reason for the cavitation mechanic act and for the microorganism cell wall destruction. The exact reason for microorganism destruction is the damage of their cell wall. Another product of the hydrodynamic cavitation in the zone of cavitational erosion is the separation of silver ions that have strong bacterium effect and force the microbiological water purification. [1]
- To specify the influence of cavitation intensity expressed by the cavitation number σ over the intensity of microorganism destruction, for each series of experiments we calculate percentage of killed microorganisms during the time of each experiment. [3]
- **3. Experimental results**
- The experimental studies results are graphically presented at the following pictures.



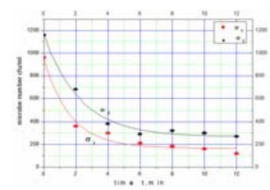
- Fig.1 Influence between time of cavitation treatment and percentage of killed microorganisms U=24V



- fig.2 Decrease of microbe number in dependence of time (per two cavitations number) U=24V.



- fig.3 Percentage of killed microorganisms in influence of time and two cavotations number U=36V.



- fig.4 Decrease of microbe number in dependence of time (per two cavitations number) U=36V.

- **4. Analyses and Conclusions**
- Fig. 1 Percentage of killed microorganisms depending on the time of the two cavitation numbers – trials at U=24V.
- According to the analysis, the percentage of killed microorganisms is much higher when the cavitation number increases. It reaches its highest level at 0-2min cavitation treatment, 69% at σ1 and 56% at σ2. From 2 to 4min the alternation of the average percent killed microorganisms at σ1 is 70% and 61% at σ2. As a whole, the percentage of killed microorganisms in the last minute of cavitation treatment compare to the control probe (non-cavitationally treated) is 91% at σ1 and 71% at σ2.
- The 4-5min performs the highest gradient of killing and the most intensive cavitation influence. After that, the percentage of killed microorganisms asymptotically reaches approximately allied values. The diagram of fig.2 relates to the same series of trials. It shows that the microorganism killing follows an exponential law at both cavitation numbers.
- Fig.3 Percentage of killed microorganisms depending on the time limits of the two cavitation numbers – trials at U=36V
- Fig 3 shows the influence of the cavitation number during third series of performed trials. The character of the curved lines stays the same as the one in the second series of trials. The influence of the bigger cavitation number is visible. The line picturing σ1 comes over the related to σ2. The gradient of the percentage of killed microorganisms is highest from 0 to 4 min. At σ1 in 4 min. we have 69%. At σ2 in 4 min. we have 67%. The curved lines, which are results of the trials after min 6 asymptotically, come closer to one another. In min 12 at σ1 (maximum cavitation number) the percentage killed microorganisms is 88% while at σ2 it is 76%. This diagram and the one of figure 1 show clearly the effect of the higher cavitation number. Figure 4 presents the diagram of the third trial series that visualize the drop of the microbe number at both cavitation numbers.
- **5. Conclusion:** Cavitation number influences the intensity of microorganisms destruction and the higher intensity of the σ (cavitation number), the bigger the influence. Its effect is strongest till min. 5, therefore, we should concentrate our studies and intensification around 4-5 min.

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