



UNIVERSITY  
“Ss. CYRIL & METHODIUS”  
FACULTY OF MECHANICAL ENGINEERING



Skopje, Republic of Macedonia

SCIENTIFIC CONFERENCE WITH  
INTERNATIONAL PARTICIPATION

# MANUFACTURING AND MANAGEMENT IN 21<sup>ST</sup> CENTURY

CONFERENCE PROCEEDINGS

CHAPTER TWO

PRODUCTION AND INDUSTRIAL ENGINEERING ASSOCIATION

Ohrid, September 16-17, 2004

M2-18	<b>Dan Dobrotă, Alin Nioață:</b> THE INFLUENCE OF GEOMETRY UPON WEARING THE TOOLS DURING THE RUBBER WASTES MINCING	100
M2-19	<b>Dan Dobrotă, Alin Nioață:</b> THE MATHEMATICAL MODELLING OF THE MINCING PROCESS OF THE RUBBER WASTES	104
M2-20	<b>Plamen Dinkov:</b> INVESTIGATION OF THE ADHESION TENSILE STRENGTH OF THERMAL SPRAYED COATINGS WITH APPLICATION IN THE CHEMICAL PLANT ENGINEERING	110
M2-21	<b>Ivan Mitev:</b> KINETICS OF DIFFUSION PROCESSES IN CARBONIZING IRON-COPPER POWDER-METALLURGIC MATERIALS	115
M2-22	<b>Sebastian Baloš, Dragan Rajnović, Marko Knežević, Leposava Šidanin, Pavel Kovač:</b> DEFORMATION OF GRAPHITE NODULES UNDER DIFFERENT LOADS	121
M2-23	<b>V. Toshkov, A. Zyumbilev:</b> INFLUENCE OF THERMAL AND THERMO-CHEMICAL TREATMENTS ON THE STRUCTURE OF STEEL 4Cr12Ni8Mn8MoVNb	126
M2-24	<b>Aleksandar Makedonski, Pavel Manolev, Boris Makedonski, Detchco Matev:</b> INTEGRATED STUDY OF THE TRIBOLOGICAL CHARACTERISTICS OF THE FERROMAGNETIC MATERIALS	132
M2-25	<b>Lyubomir Stanev, Georgi Komitov:</b> EFFECT OF REPAIR-RESTORE TECHNOLOGY „XADO” ON PROPERTY OF WORK SURFACE IN WEAR OUT PROCESS	137
M2-26	<b>Nikolai Kutcharov , Hristo Streshkov, Dimiter Stankov:</b> ELECTRO-CHEMICAL METHOD FOR LINKING ALUMINUM ALLOYS BARRELS IN „ARSENAL” JSK	141
M2-27	<b>Dimko Dimeski, Dijana Spaseska, Zore Angelevski:</b> COMPOSITE MATERIALS FOR PERSONAL BALLISTIC PROTECTION	145
M2-28	<b>Danijel Šogorović:</b> AN ANALYSIS OF PRODUCTION OF COMPOSITE PARTS BY FILAMENT WINDING WITH SYSTEM'S THEORY	151
M2-29	<b>Milena N. Koleva, Grigor A. Boijadjijyski:</b> NON-ASBESTOS FRICTION COMPOSITE MATERIAL BASED ON UP/SB AND UP/SBR POLYMER SYSTEMS	155
M2-30	<b>Boris Jankovski, Ljuban Dudeski:</b> NEW MATERIAL AN TECHNOLOGY FOR FIRE DISTINGUISHER	161
M2-31	<b>Vineta Srebrenkoska, Gordana Bogoeva-Gaceva, Dime Dimeski:</b> FEATURES OF PULTRUDED MATERIALS WITH DIFFERENT TYPES OF POLIMER MATRECES	167
M2-32	<b>Dijana Spaseska, Jadranka Blazevska-Gilev:</b> TECHNOLOGY TRANSFER FOR POLYMER WASTE RECYCLING	173
M2-33	<b>Rozeta Evtimova , Rositsa Madjarova, Denitsa Georgieva, Hans-Dieter Hunger, Gerhard Behrendt:</b> POLYMER WOOD COMPOSITES BASED ON RECYCLING PRODUCTS FROM CONDENSATION POLYMERS	177
M2-34	<b>Jasmina Caloska, Valentino Stojkovski, Dimitri Kozinakov:</b> INFLUENCE OF PERCENTAGE OF RECYCLED MATERIAL INTO THE BASIC MATERIAL TO THE MECHANICAL CHARACTERISTICS OF PE100 PIPES	183
M2-35	<b>Donka Bodurova, Milcho Angelov:</b> INTENSIFICATION THE PROCESS OF WATER PURIFICATION BY HYDRODYNAMIC CAVITATION	189
M2-36	<b>Salah-Eldien Omer, Minka Čehić:</b> RATIONALIZATION USING OF WOODEN MASS TO APPLICATION IN CIVIL ENGINEERING	195

## **INTENSIFICATION THE PROCESS OF WATER PURIFICATION BY HYDRODYNAMIC CAVITATION**

Donka Bodurova, Ph. D. student  
e-mail: [bodurova@evrocom.net](mailto:bodurova@evrocom.net)

Milcho Angelov, Docent Dr  
e-mail: [mangelov@filibeto.org](mailto:mangelov@filibeto.org)

UNIVERSITY OF FOOD TECHNOLOGIES 26, "MARITZA" BLVD, BG 4002 PLOVDIV,  
BULGARIA , tel: ++359 32 603 840, fax: ++359 32 644 102

### **ABSTRACT**

*Hydrodynamic cavitation damages the apparatus by cavitation erosion of the elements in a hydro system. Being acquainted with the mechanisms of effect, hydrodynamic cavitation can be used positively to intensify technological processes. The objectives of the work are experimental exploration of the possibilities for microbiological water purification through processing in conditions of different cavitation numbers. To intensify the purifying process series of experiments, at different levels of intensity of the electrical field in the zone of cavitation, are presented. These experiments substantiate the idea of the microbiological purification of nature and wastewaters via cavitation and represent a huge range of opportunities for applying this method in various industrial fields.*

*Keywords: cavitation, water purification, microbe number.*

### **1. Introduction**

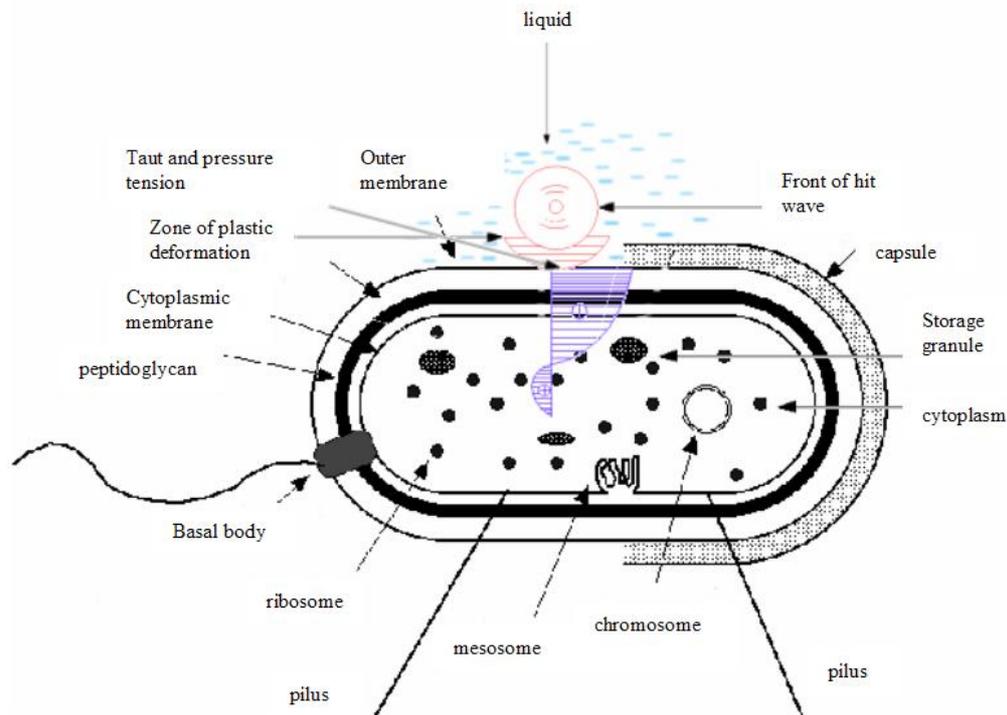
Hydrodynamic cavitation is a method with effective use in destroying of elements of hydrosystems and complex organic chemicals, biorefraction materials, etc. Pulsation of pressure and speed alternation are results of the varying geometrical conditions in a cavitation area. [1,2]

Hydrodynamic cavitation has a dual effect: local and total. The local one reflects in accumulating ability of a separate cavitation cavern to release built-up energy of condensed type. The two major hypotheses that describe this phenomenon are the symmetric and non-symmetric collapse. Cavitation 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 cavitation 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 contaminants is a result of the local effect of cavitation. For water the speed of the micro steam is about 100 m/s; however, there are cases when it exceeds this value and reaches 550 m/s at more high-pressure gradients. No living cell can resist 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 (fig. 1). 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**

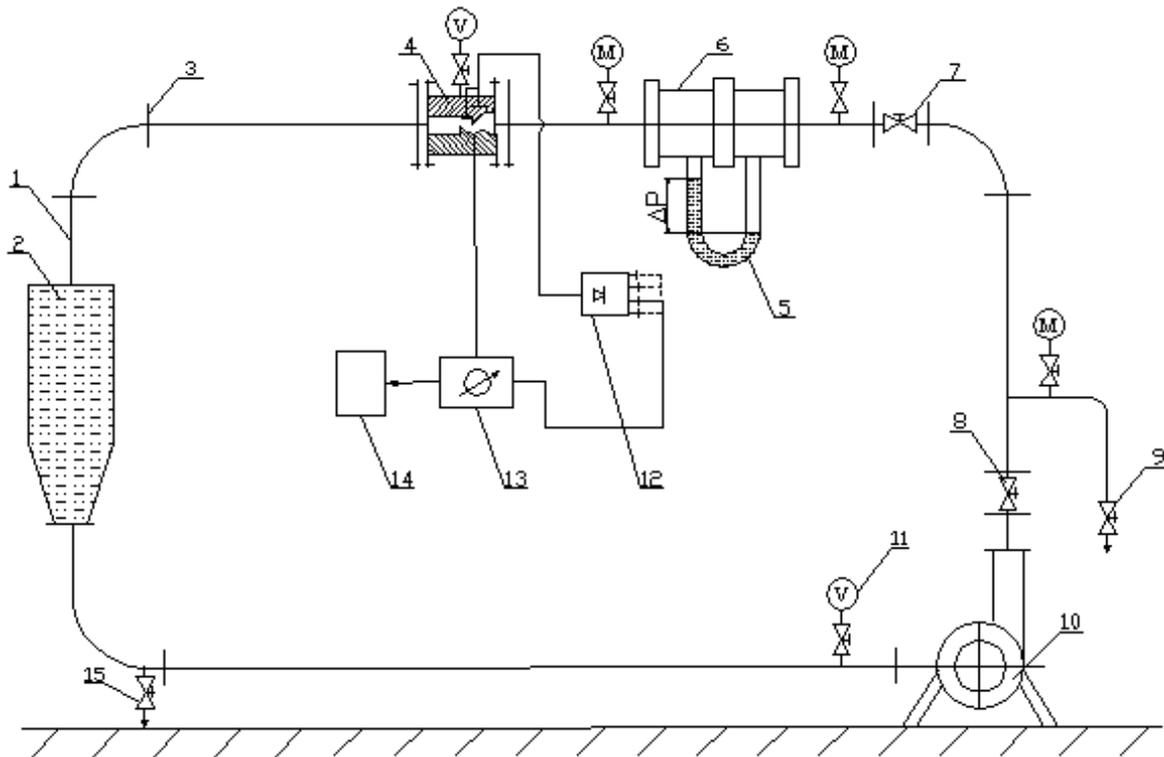
Microorganisms resist high pressure and mechanic impacts. Many bacteria can withstand more than 100 Pa pressure. Microorganisms' resistance varies in a wide range. When pressure is exercised over atmosphere of some gases like O<sub>2</sub>, CO<sub>2</sub>, etc., microorganisms become sensible and their 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, actinomycets 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 laboratory installation is on fig. 2.

Before each experiment starts, we take a 10 ml 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]

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 cavitation 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  $\sigma$  over the intensity of microorganism destruction, for each series of experiments we calculate percentage of killed microorganisms during the time of each experiment. [3]



**Fig.2. Scheme of the 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 – reectifier; 13 – digital multimeter; 14 – computer; 15 – valve to take tests.

### 3. Experimental results

The experimental studies results are graphically presented at the following pictures – fig.3 –fig. 6.

### 4. Analyses and conclusions

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  $\sigma_1$  and 56% at  $\sigma_2$ . From 2 to 4min the alternation of the average percent killed microorganisms at  $\sigma_1$  is 70% and 61% at  $\sigma_2$ . 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  $\sigma_1$  and 71% at  $\sigma_2$  - fig. 3.

The 4-5 min 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. 4 relates to the same series of experiments. It shows that the decreasing of the microbe number follows an exponential law at both cavitation numbers.

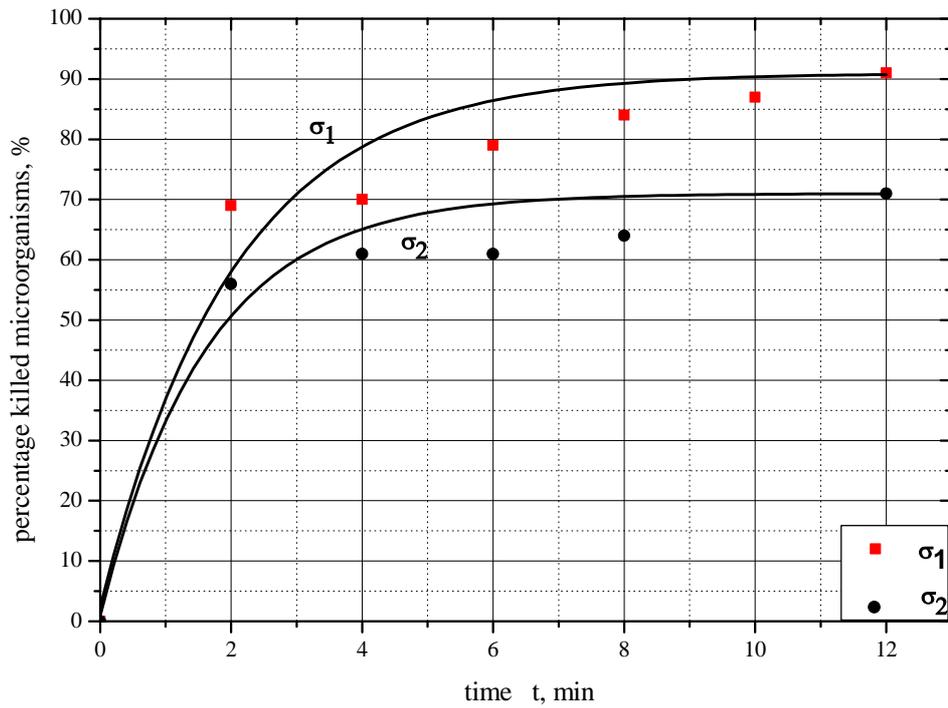


Fig.3. Influence between time of cavitation treatment and percentage of killed microorganisms at U=24V.

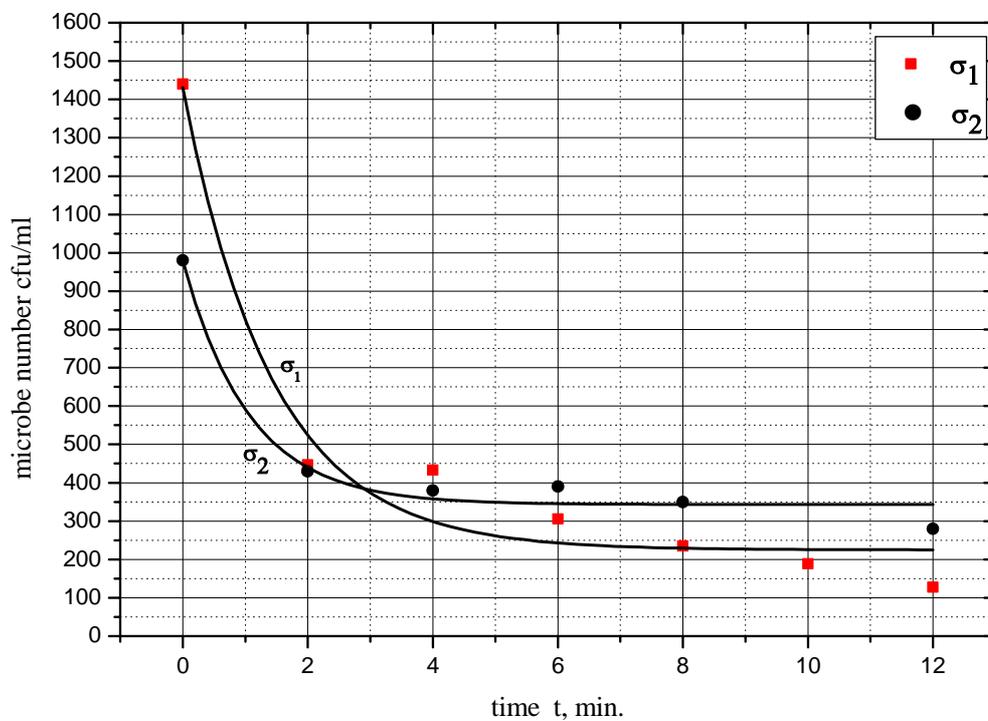


Fig.4. Decrease of microbe number in dependence of time (per two cavitation numbers) at U=24V.

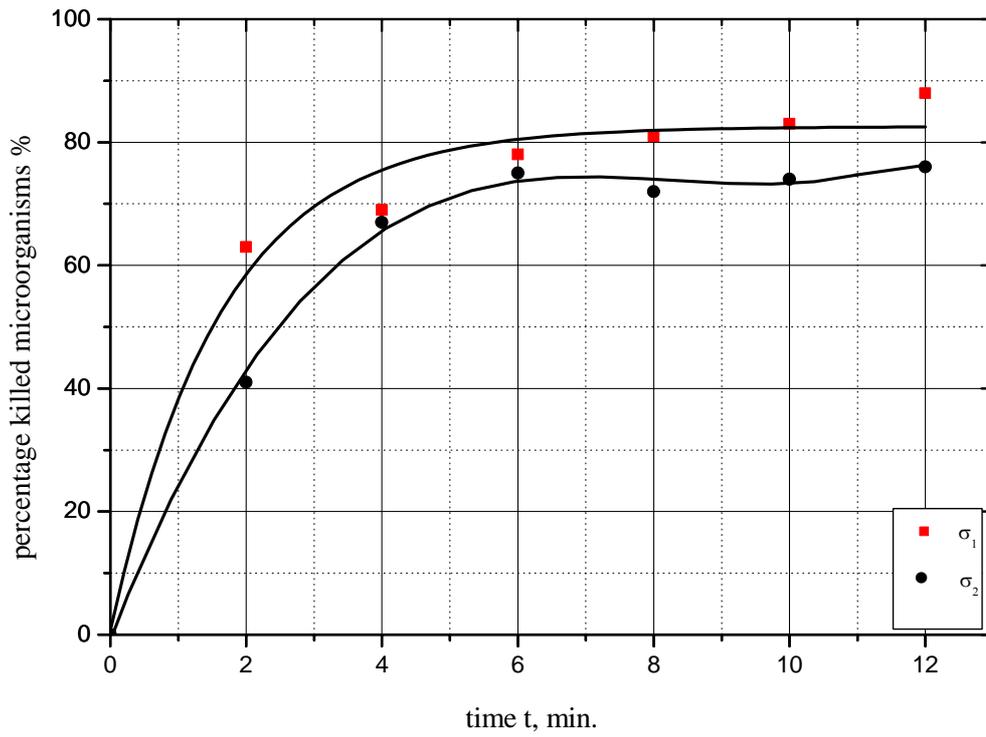


Fig. 5. Percentage of killed microorganisms in influence of time and two cavitation numbers at  $U=36V$ .

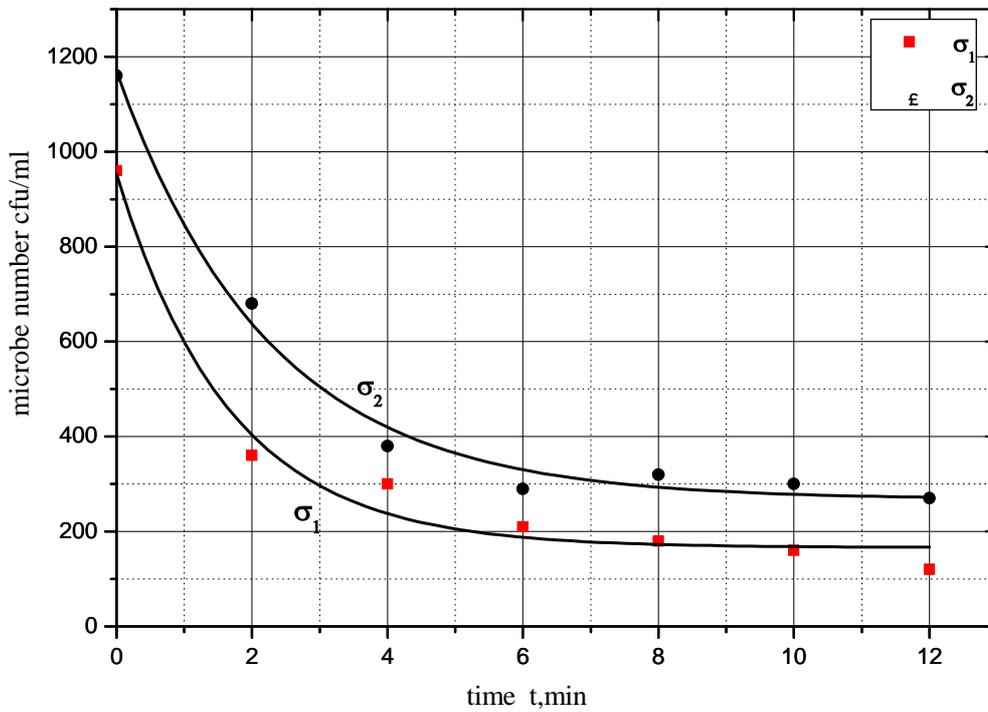


Fig. 6. Decrease of microbe number in dependence of time (per two cavitation numbers) at  $U=36V$ .

Fig 5 shows the influence of the cavitation number during the second series of performed experiments. The character of the curved lines stays the same as the one in the first series of experiments. The influence of the bigger cavitation number is visible. The line picturing  $\sigma_1$  comes over the related to  $\sigma_2$ . The gradient of the percentage of killed microorganisms is highest from 0 to 4 min. At  $\sigma_1$  in 4 min. we have 69%. At  $\sigma_2$  in 4 min. we have 67%. The curved lines, which are results of the experiments after min 6 asymptotically, come closer to one another. In min 12 at  $\sigma_1$  (maximum cavitation number) the percentage killed microorganisms is 88% while at  $\sigma_2$  it is 76%. This diagram and the one of figure 3 show clearly the effect of the higher cavitation number. Figure 6 presents the diagram of the second experiment series that visualize the drop of the microbe number at both cavitation numbers.

Cavitation number influences the intensity of microorganisms destruction and the higher intensity of the  $\sigma$  (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.

We can use an electrical field in the zone of cavitation also for intensification of microorganisms destruction.

## 5. References

- [1] Gogate P., Cavitation: an auxiliary technique in wastewater treatment schemes, "Advances in Environmental Research Journal ", 6, 2002.
- [2] Pandit A., Jyoti K., Hybrid cavitation methods for water disinfection. "Biochemical Engineering Journal" 14, 2003.
- [3] Pandit A., Wastewater treatment: a novel energy efficient hydrodynamic cavitation technique. "Ultrasonics Sonochemistry" 9, 2002.
- [4] Pandit A., Water disinfection by acoustic and hydrodynamic cavitation. "Biochemical engineering Journal ", 7, 2001.
- [5] Hargreaves D., Pai R., Performance of environment-friendly hydraulic fluids and material wear in cavitating conditions. "Wear", 2002.
- [6] Tomita Y., Growth and collapse of cavitation bubbles near a curved rigid boundary. "Fluid Mechanics", vol. 466, 2002.
- [7] Tomita Y., *Shock focusing effect in medical science and sonoluminescence*. Springer, 2003.