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EXPERIMENTAL STUDY OF CAVITATION-HYDRODYNAMIC LUMINESCENCE IN GAS-LIQUID ENVIRONMENT

The article presents the results of the study of cavitation processes in technological equipment related to analytical phenomena that are accompanied by cavitation. One of the important factors accompanying cavitation processes is hydrodynamic luminescence. The information analysis of the existing theories of luminescence formation, including at hydrodynamic processes in liquids and gas-liquid environments is carried out that allowed to substantiate the basic conditions which provide emergence of the phenomenon of hydroluminescence. A literature search revealed that there is no unambiguous theory of the nature of sonoluminescence and hydroluminescence. These processes have several theories of their origin: thermal, electrical, quantum and even nuclear. Moreover, each theory is to some extent confirmed by the experiments of scientists, but at the same time is not fully disclosed. This ambiguous interpretation leads to the conclusion that the current situation cannot be considered satisfactory. Detailed experimental studies of this phenomenon are needed. For the practical study of the mechanisms of hydrodynamic luminescence, an experimental stand based on a hydrodynamic cavitator was developed and manufactured. This stand allows to investigate the cost characteristics of the cavitator, to observe and make photo and video fixation of the phenomenon of hydroluminescence in the flow of liquid or gas-liquid mixture, for which an ejector mixer was used. As a result of application of experimental-analytical method and technical visualization it is established that the phenomenon of hydroluminescence begins at an oil pressure of 20 bar, and at its saturation with inert gas – occurs at much lower pressures within 10 bar. According to our observations, with increasing flow velocity in the narrowing region, cavitation first occurs, then, with a further increase in the flow velocity, single sparks begin to appear, and at some point there is a "breakdown" and a stable glow. Based on the results of processing and analysis of experimental studies, a conceptual model of the stages of origin and development of the cavitation process and the accompanying effects is built. The conducted researches allowed to reveal the cavitation zones arising in the cavitator. Cavitation areas were identified with the help of high-speed video recording and the mechanism of its development was investigated. In addition, the visualized characteristics of the closed volume to some extent clarify the existing ideas about the behavior of the liquid and gas-liquid mixture in the nozzle. It is concluded that the phenomenon of hydroluminescence (triboluminescence) can be used as a method of cavitation visualization. At the same time, the management of workflows that accompany the phenomenon of cavitation is quite relevant because it allows you to deal with the undesirable consequences of cavitation.

Keywords: luminescence, cavitator, cavitation, sonoluminescence, hydroluminescence, triboluminescence, throttle, ejector, gas-liquid mixture, visualization of liquid flow, point temperature, viscosity, cavitation number, liquid flow rate, spectroscopy.

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ЕКСПЕРИМЕНТАЛЬНЕ ДОСЛІДЖЕННЯ КАВІТАЦІЙНО-ГІДРОДИНАМІЧНОЇ ЛЮМІНЕСЦЕНЦІЇ В ГАЗО-РІДИННОМУ СЕРЕДОВИЩІ

У статті представлені результати дослідження кавітаційних процесів у технологічному обладнанні, пов'язаних з аналітичними явищами, що супроводжуються під час кавітації. Одним з важливих факторів, що супроводжують кавітаційні процеси являється гідродинамічна люмінесценція. Проведено інформаційний аналіз існуючих теорій утворення люмінесценції, в тому числі при гідродинамічних процесах в рідинах і газо-рідинних середовищах, що дозволило обґрунтувати основні умови, які забезпечують виникнення явища гідролюмінесценції. Проведений літературний пошук виявив, що не існує однозначної теорії природи виникнення сонолюмінесценції і гідролюмінесценції. Дані процеси мають кілька теорій їх виникнення: теплова, електрична, квантова і навіть ядерна. Причому кожна теорія в якійсь мірі підтверджується дослідами вчених, але в той же час не є повністю розкритою. Таке неоднозначне трактування призводить до висновку, що ситуацію, що склалася не можна вважати задовільною. Необхідні розгорнуті експериментальні дослідження даного явища. Для практичного вивчення механізмів виникнення гідродинамічної люмінесценції був розроблений і виготовлений експериментальний стенд на основі гідродинамічного кавітатора. Даний стенд дозволяє досліджувати витратну характеристику кавітатора, спостерігати і робити фото- і відео фіксацію явища гідролюмінесценції в потоці рідини або газо-рідинній суміші, для отримання якої використовувався ежекторний змішувач. В результаті застосування експериментально-аналітичного методу і технічної візуалізації встановлено, що явище гідролюмінесценції починається при тиску масла 20 бар, а при його насиченні інертним газом – відбувається при значно менших тисках в межах 10 бар. За нашими спостереженнями, зі збільшенням швидкості потоку в області звуження спочатку виникає кавітація, потім, при подальшому збільшенні швидкості потоку, починають з'являтися поодинокі іскри, а з певного моменту відбувається «пробій» і встановлюється стабільне свічення. За результатами обробки і аналізу проведених експериментальних досліджень побудована концептуальна модель етапів виникнення і розвитку процесу кавітації і супутніх цьому ефектів. Проведені дослідження дозволили виявити кавітаційні зони, що виникають в кавітаторі. З допомогою швидкісної відеозйомки були виявлені області кавітації і досліджено механізм її розвитку. Крім того, отримані за рахунок візуалізації характеристики замкнутого обсягу певною мірою прояснюють існуючі уявлення про поводження рідини і газо-рідинної суміші в соплі. Зроблено висновок, що явище гідролюмінесценції (триболюмінесценції) може використовуватись як метод візуалізації кавітації. У той же час керування робочими процесами, які супроводжують явище кавітації, є досить актуальним, оскільки дозволяє боротися з небажаними наслідками кавітації.

Ключові слова: люмінесценція, кавітатор, кавітація, сонолюмінесценція, гідролюмінесценція, триболюмінесценція, дросель, ежектор, газо-рідинне середовище, візуалізація потоку рідини, точкова температура, в'язкість, кавітаційне число, швидкість потоку рідини, спектроскопія.

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ЭКСПЕРИМЕНТАЛЬНОЕ ИССЛЕДОВАНИЕ КАВИТАЦИОННО-ГИДРОДИНАМИЧЕСКОЙ ЛЮМИНЕСЦЕНЦИИ В ГАЗО-ЖИДКОСТНОЙ СРЕДЕ

В статье представлены результаты исследования кавитационных процессов в технологическом оборудовании, связанных с аналитическими явлениями, сопровождающимися при кавитации. Одним из важных факторов, сопровождающих кавитационные процессы является гидродинамическая люминесценция. Проведен информационный анализ существующих теорий образования люминесценции, в том числе при гидродинамических процессах в жидкостях и газо-жидкостных средах, что позволило обосновать основные условия, которые обеспечивают возникновения явления гидролюминесценции. Проведенный литературный поиск обнаружил, что не существует однозначной теории природы возникновения сонолюминесценции и гидролюминесценции. Данные процессы имеют несколько теорий возникновения: тепловая, электрическая, квантовая и даже ядерная. Причем каждая теория в какой-то степени подтверждается опытами ученых, но в то же время не является полностью раскрытой. Такое неоднозначное трактование приводит к выводу, что ситуацию нельзя считать удовлетворительной. Необходимы развернутые экспериментальные исследования данного явления. Для практического изучения механизмов возникновения гидродинамической люминесценции был разработан и изготовлен экспериментальный стенд на основе гидродинамического кавитатора. Данный стенд позволяет исследовать расходную характеристику кавитатора, наблюдать и делать фото и видео фиксацию явления гидролюминесценции в потоке жидкости или газо-жидкостной смеси, для получения которой использовался эжекторный смеситель. В результате применения экспериментально-аналитического метода и технической визуализации установлено, что явление гидролюминесценции начинается при давлении масла 20 бар, а при его насыщении инертным газом – происходит при значительно меньших давлениях в пределах 10 бар. По нашим наблюдениям, с увеличением скорости потока в области сужения сначала возникает кавитация, затем, при дальнейшем увеличении скорости потока, начинают появляться единичные искры, а с определенного момента происходит «пробой» и устанавливается стабильное свечение. По результатам обработки и анализа проведенных экспериментальных исследований построена концептуальная модель этапов возникновения и развития процесса кавитации и сопутствующих этому эффектов. Проведенные исследования позволили выявить кавитационные зоны, возникающие в кавитаторе. С помощью скоростной видеосъемки были обнаружены области кавитации и исследован механизм её развития. Кроме того, полученные за счет визуализации характеристики замкнутого объема в определенной степени проясняют существующие представления о поведении жидкости и газо-жидкостной смеси в сопле. Сделан вывод, что явление гидролюминесценции (триболюминесценция) может использоваться как метод визуализации кавитации. В то же время управления рабочими процессами, которые сопровождают явление кавитации, является весьма актуальным, поскольку позволяет бороться с нежелательными последствиями кавитации.

Ключевые слова: люминесценция, кавитатор, кавитация, сонолюминесценция, гидролюминесценция, триболюминесценция, дроссель, эжектор, газо-жидкостная среда, визуализация потока жидкости, точечная температура, вязкость, кавитационное число, скорость потока жидкости, спектроскопия.

Introduction. The phenomenon of luminescence can be interpreted as the light radiation of substances that is excess over their thermal radiation at a given temperature and excited by a certain energy source. Such sources can be radioactive, X-ray or light radiation, chemical reactions, mechanical actions, electric fields, etc. (Table 1).

Table 1 – Types of luminescence

Types of luminescence (by the method of excitation of molecules)	
Photoluminescence	Excitation by visible or ultraviolet radiation
X-ray luminescence	X-ray excitation
Cathodoluminescence	Luminescence of a phosphor when bombarded by electrons (cathode jets)
Radioluminescence	Glow under the action of nuclear radiation (alpha parts, beta parts, gamma radiation, protons, etc.)
Chemical luminescence (bio-chemical luminescence)	Glow due to the energy of chemical (and biochemical) reactions
Electroluminescence	Glow of phosphors in electric fields
Sonoluminescence	Excitation by sound or ultrasound
Triboluminescence	Luminescence as a result of deformation during rubbing, destruction of mechanical particles
Hydrodynamic luminescence	Emission of light by the liquid arising at cavitation of the bubbles caused exclusively by hydrodynamic effects

In the elements and devices of modern hydraulic systems, the working pressure can reach up to 2000 bar [1, 2]. In the throttle elements of hydraulic equipment, the flow of working fluid has a pronounced turbulent nature. At a high speed of the working fluid in the throttle elements there is cavitation and the associated active release of bubbles of undissolved air and steam [2–5].

Cavitation leads to a number of physicochemical processes, may be accompanied by cavitation chemical reactions, oxidation, destruction, destruction of molecules and luminescence. Rapid collapse of vapor-gas bubbles-caverns, according to the laws of thermodynamics, can cause a local increase in temperature up to 1500 K, and under certain conditions, and light radiation of liquid or radiation of light quanta (electronic breakdown [1]).

The effect of hydroluminescence (GL) was first discovered by Konstantinov in 1947 [6]. With a flat flow of water of a solid body (round cylinders) in the flat channel there was a glow behind the cylinders, with highly developed hydrodynamic cavitation.

In 1964, Jarman and Taylor recorded a weak luminescent glow of water in the area of the cavitation cavities in the Venturi tube. In his dissertation, Peterson [2] in 1966 also noted light radiation in the field of bubbling during hydrodynamic cavitation.

In the 70s of the twentieth century Koldomasov A. I. the glow of distilled water flowing in a narrow channel was detected [7]. The nature of light radiation was explained by plasma discharges during water cavitation, but the cause of the discharges and the source of plasma formation were unclear.

In 2004, Pilgunov V. N. and Efremova K. D. found intense light radiation during the passage of mineral oil through the diaphragm throttle [2].

Later (2007–2010) similar phenomena were found in the study of cavitation in organic liquids flowing at high speed in narrow dielectric channels [5].

The information analysis of the sources showed that there is no unambiguous theory of hydrodynamic luminescence and unambiguous interpretation of its nature.

The largest number of results of experimental and theoretical works indicates that the processes of hydrodynamic luminescence have an electrical nature of origin, but there are also a number of works in which arguments are made in favor of thermal theory.

Electrical theory is based on electrical phenomena inside the bubble itself or its interaction with near-caviting bubbles. As a substantiation of this theory, the messages about the correspondence of the continuous spectrum observed during sonoluminescence to the radiation spectrum of an absolutely black body play a certain role.

Even in [8], light radiation was associated with electric discharges in the liquid. The electrical effects that accompany the flow of liquid at high pressure were directly observed in [5, 6], in [4] a similar conclusion was made as a result of indirect measurements. In general, the relationship between cavitation and electric discharges can be important for understanding the physical nature of the breakdown of liquid dielectrics.

However, detailed ideas about the mechanism of hydroluminescence are still unclear. Which phases – gas (bubble), liquid (flowing liquid itself) or even solid (channel wall) – are responsible for light radiation, to what extent can this physical mechanism be applied to sonoluminescence as a phenomenon in general?

For example, in [9] the crucial role is played by the emission of electrons from the wall, which adhere to the molecules of the liquid with the release of photons.

The thermal theory is based on the assumption that when exposed to a cavitation bubble, high temperatures are formed inside it, which stimulate the emission of radiation by the bubble.

The thermal theory of hydrodynamic luminescence was proposed by Koldamasov [7], pointing out in his article that the source of luminescence is a plasma clot formed with an average temperature. 10^4 K.

Proponents of the thermal theory of hydrodynamic luminescence include Gordeyev and Serbinov [10, 11]. In a series of experiments to study the excitation of an explosion in liquid explosives in [11] it was found that the initiation of an explosion by cavitation does not occur during expansion, but during the closure of the cavitation cavity in the explosive liquid. Based on the obtained results, the authors [10, 11] concluded that the cause of light emission during hydrodynamic luminescence is the thermal processes that occur during cavitation.

There are also other variants of thermal theory. According to Griffing's hypothesis, light radiation in water occurs during radical recombination H^+, OH^-, formed by thermal hemolytic dissociation of water. Jarman considered the closure of a cavitation bubble as a microscopic shock tube in which, when the bubble is compressed, the shock waves are focused, and the light radiation corresponds to a thermal process. The possibility of excitation of thermonuclear reactions in a sonoluminescence bubble is expressed by the authors, and there is also refuting this possibility of the article [12].

There is also a hypothesis based on **quantum theory**, which was proposed by the famous physicist Julian Schwinger [13] and discussed in more detail in an article by Claudia Eberlein of the University of Sussex (UK).

Eberlane [14] assumes that sonoluminescence during cavitation is generated by a vacuum inside bubbles, similar to Hawking radiation, ie radiation emitted on the horizon of black hole formation. Quantum theory states that a vacuum contains "virtual" particles. According to this explanation of vacuum energy, the rapidly moving interface between a liquid and a gas converts "virtual" photons into real photons.

This hypothesis is based on the consideration of changes in the vacuum state of the electromagnetic field in the bubble in the process of rapid change in the shape of the latter, in terms of close to that usually used in describing the Casimir effect. For example, when considering the vacuum state of an electromagnetic field in a flat capacitor, depending on the boundary conditions defined by the plates.

However, some authors have argued that sonoluminescence releases too much energy in a very short time interval to match the explanation of vacuum energy [15], although other reliable sources claim that the explanation of vacuum energy may be correct [16].

If this is true, then sonoluminescence is the first example in which radiation associated with a change in the vacuum state is directly and experimentally observed.

Some researchers have proposed and substantiated the theory of nuclear fusion on the grounds that the actual temperatures in sonoluminescent systems can be much higher than 20,000 K. Some studies claim that the measured temperatures reach 100,000 K, and suggest that the temperature can reach millions of kelvins [17]. Such a high temperature can cause fusion. This phenomenon is sometimes called "bubble fusion" and is compared to the implosion scheme used in the thermonuclear component of thermonuclear weapons.

In 2006, researchers from the Rensseler Polytechnic Institute (USA) stated that in experiments on sonoluminescence produced nuclear fusion [18, 19].

R. P. Taleyarkhan's experiments conducted in 2002 and 2005 using deuterium acetone showed that he was able to reach temperatures of the order of millions of kelvins in a sonoluminescent flash, observing the products of the thermonuclear reaction: tritium and neutrons. Confirmation of the results of these experiments would allow to obtain a compact thermonuclear reactor. However, the experiments were considered poor, and doubts were expressed about the report of the author's scientific discovery. This report has lost interest among the scientific community.

This paper presents the results of studies of the phenomenon of hydroluminescence, ie the emission of light by a liquid, which occurs during the cavitation of bubbles caused by hydrodynamic effects in a gas-liquid medium.

The main processes that accompany hydrodynamic luminescence are:

- sound;
- luminescence;
- local temperature rise;
- hydraulic shocks and pressure pulsation, etc.

Cavitation can cause many effects (Fig. 1).

Hydrodynamic luminescence (HL) is the emission of light by a liquid in a narrow channel. It can be explained that HL is caused by friction, so this is also a special case of mechanical luminescence, which occurs when grinding, crushing or splitting crystals – triboluminescence. That is, HL is the triboluminescence of the fluid.

HL spectroscopy gives us information about the conditions in the fluorescent liquid – exactly, about the conditions in the bubbles, because the main source of light is the emission of gas into the air bubbles. The HL spectrum gives a clear light of non-equilibrium plasma radiation in bubbles.

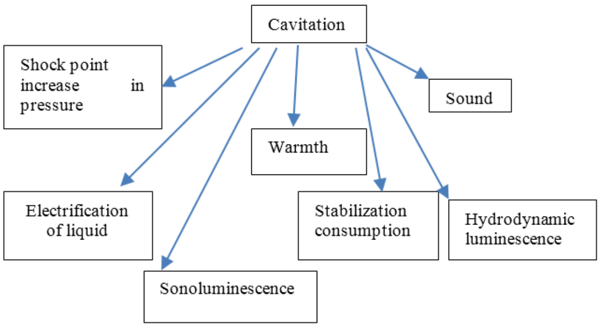


Fig. 1 Cavitation processes and effects

Thus, the effect of hydrodynamic luminescence is electrical. The insert material, in the zone of intense cavitation, emits electrons that are transferred by the flow, and at the inlet edge of the holes a positive charge of high density is formed, the potential of which relative to the ground can reach kilovolts.

What is the drag when flowing around solids with a stream of liquid or gas – it is well known. However, in addition to the drag, when flowing there is a so-called wave resistance, which is the result of energy consumption for the formation of acoustic or shock waves. In gases, for example, shock waves occur during the formation of a jump seal in the frontal surface of the body when flowing around it by a supersonic gas flow. At formation of a jump of consolidation density, temperature, pressure, speed of substance of a stream sharply increase, as a result processes of dissociation and ionization of the molecules which are followed by powerful light radiation can take place. Light radiation can greatly heat both the gas in front of the wave front and the surface of a moving body.

The questions related to the description of the stages of luminescence in the fluid flow during hydrodynamic cavitation are quite complex, which until recently remain completely unexplored. This is especially true of the multicomponent medium, which includes oil and petroleum products (hydraulic oils). In this regard, we consider hydrodynamic luminescence from the standpoint of physicochemistry and the most well-founded two theories of origin – thermal and electrical. Information about the formation of luminescence is especially important for cavitation technologies, as at this level when closing the bubble in oscillations can release significant energy, which is often used for high-quality mixing of media, their separation and destruction at the molecular level, polarization, etc. So, for example, it is established that at fluctuation of small gas bubbles in water, in a compression phase, in a short period of time 10^{-8}–10^{-9} с, order pressures may occur 10^3 МПа and "point" temperature 10^4 °С.

Sufficiently high energy is released in a short time when the bubble closes, when an area of high pressure appears in the local area (to $4\cdot10^3$ МПа) and intense jet flow with cumulative microcurrent velocities 300–500 м/с. During a pulsed discharge, radiation occurs: ionizing, acoustic waves, electromagnetic fields and high-speed fluxes with the occurrence of cavitation when closing the discharge zone [1].

Visualization and study. A sample with a transparent plexiglass cylinder was used for visualization (Fig. 2).

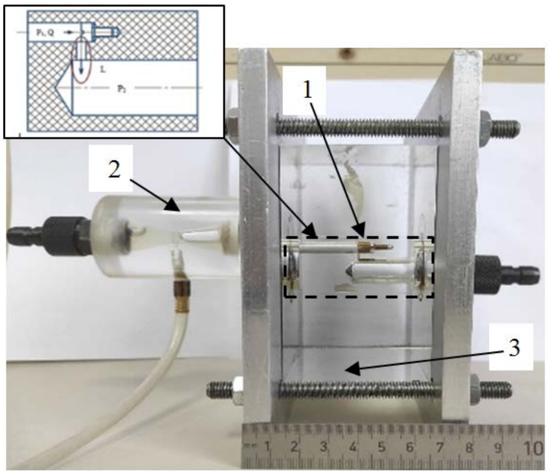


Fig. 2. Design of a model (sample) of research:
1 – reactor; 2 – ejector; 3 – body

The experiments were performed at a pressure drop to 5 МПа and consumption to 10^{-5} $м^3/с$. The sample was connected to the hydraulic system according to the scheme (Fig. 3).

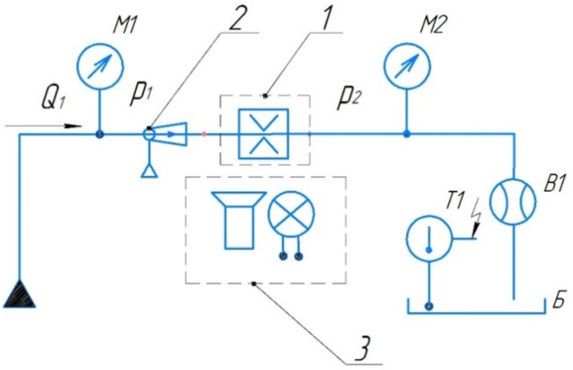


Fig. 3. Schematic hydraulic diagram of the test bench:
1 – cavitator; 2 – ejector; 3 – speed video camera

The main parameters that were controlled: the level of inlet pressure, the pressure drop at the inlet and outlet of the sample, flow rate and outlet temperature. The temperature of the working fluid was monitored in the apparatus using a reference thermocouple. Experimental studies on the rotary mode using the working fluid type "H-L". Processing on the sample of the piston valve was carried out by the camera at a speed of 120–1000 frames per second. Studies were conducted to obtain data describing the structure and parameters of the flow (Fig. 4).

The amount of gases in the bubbles depends on the number of cavitation. Critical flow parameters and depending on the height and velocity of the pressure, indicating the beginning of the cavitation of the flow, can be calculated [1]:

$$\chi = \frac{2(p_1 - p_2)}{\rho \cdot V_1^2},$$

where p_1, V_1 – pressure and flow rate, for example at the inlet of the valve; p_2 – vapor pressure; ρ – fluid density.

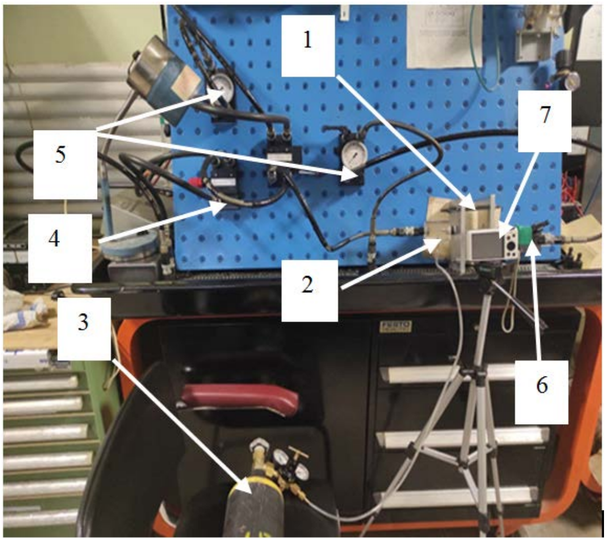


Fig. 4. Schematic diagram of hydraulic test stand:
1 – cavitator; 2 – ejector; 3 – system for saturation of the liquid flow with noble gases; 4 – safety valve; 5 – manometers at the inlet and outlet; 6 – temperature sensors; 7 – speed camera

The method of experimental research consisted of the following actions. Setting the required pressure drop on the apparatus, the temperature of the working fluid was controlled by a reference thermocouple and measured the volumetric flow rate. According to the results of the study, a number of images were obtained, which are presented in Table 2.

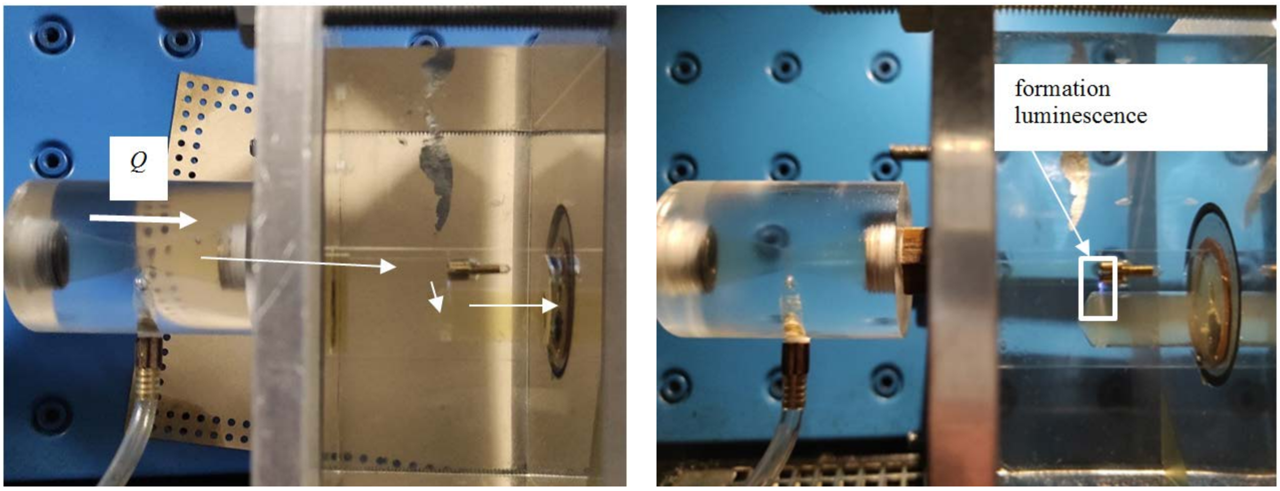
Investigation of the influence of inert gas saturation on hydrodynamic luminescence. According to the results of the study, a number of images were obtained, and it is possible to draw conclusions about the effect of noble gas saturation on the intensity of luminescence that occurs behind the screw in the throttle channel.

Table 2 – Conditions for conducting experiments

Conditions for the experiment	Parameters	Picture
Without saturation	Δp = 2 MPa, oil temperature t = 33 °C, Q = 0,000012 m^3/s, throttle area 0,00003 m^2, v_{thr} = 25 m/s	Fig. 5, *a*, *b*
Without saturation	Δp = 5 MPa, oil temperature t = 33 °C, Q = 0,0000004 m^3/s, throttle area 0,00003 m^2, v_{thr} = 100 m/s	Fig. 6, *a*
Nitrogen saturation	Δp = 5 MPa, oil temperature t = 33 °C, Q = 0,0000004 m^3/s, throttle area 0,00003 m^2, v_{thr} = 100 m/s	Fig. 6, *b*
Argon saturation	Δp = 5 MPa, oil temperature t = 33 °C, Q = 0,0000004 m^3/s, throttle area 0,00003 m^2, v_{thr} = 100 m/s	Fig. 6, *c*
A mixture of gases Nitrogen + Argon	Δp = 5 MPa, oil temperature t = 33 °C, Q = 0,0000004 m^3/s, throttle area 0,00003 m^2, v_{thr} = 100 m/s	Fig. 6, *d*

In Fig. 5, 6 show images for different stages of luminescence with saturation and without saturation (argon and nitrogen) (single-phase, two-phase flow).

Thus, observations show that the least intense luminescence was observed without additional saturation of the liquid with noble gases (Table 2). Thus, we can assume that the luminescence intensity will increase with gas saturation. To test this hypothesis, a stand was developed to investigate the effect of gas saturation on the luminescence effect. Saturation was due to the use of a specially designed ejector before entering the cavitator.



a *b*

Fig. 5. The results of experiments:
a – without luminescence; *b* – "shot" appearance of luminescence

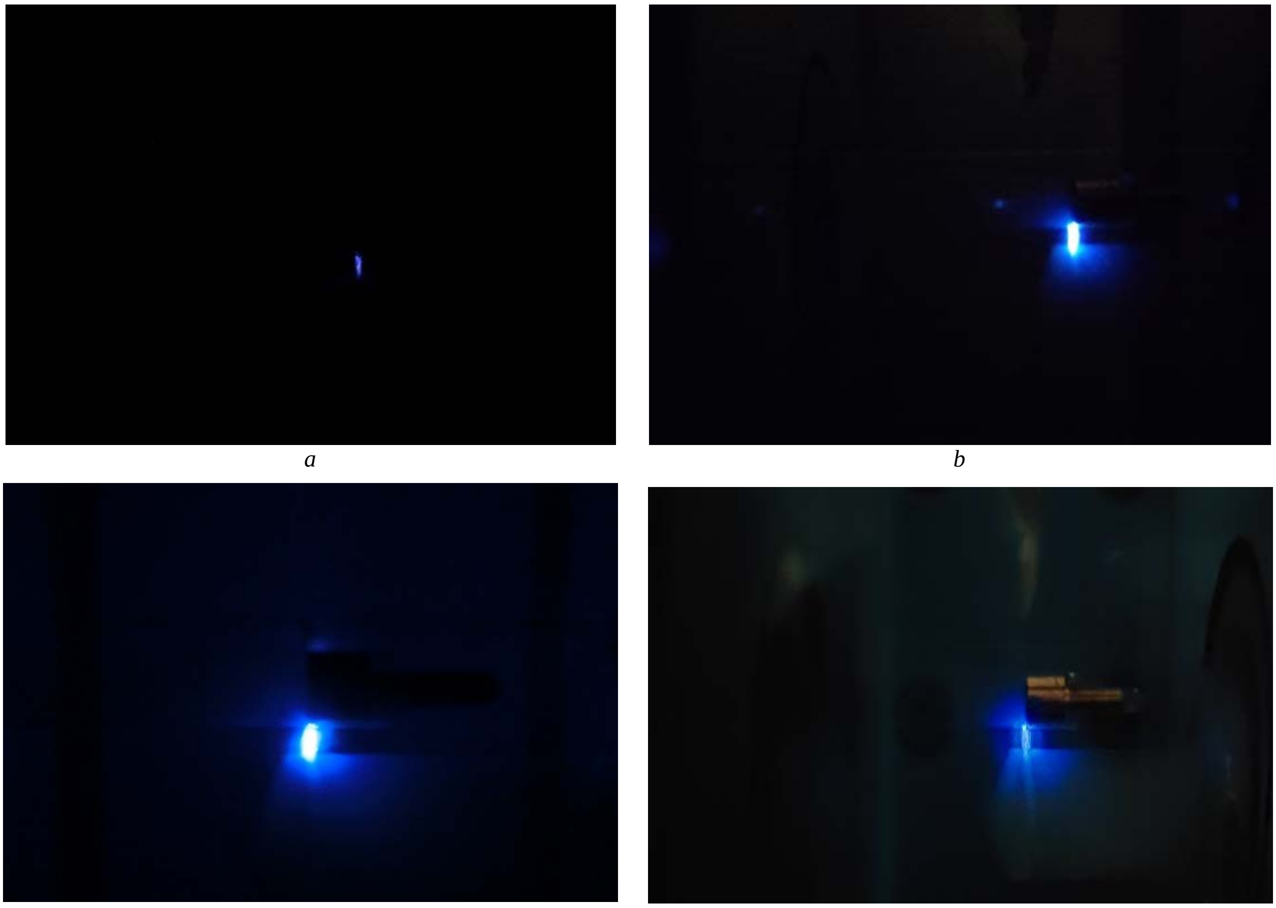

a *b* *c* *d*

Fig. 6. Emission of light in mineral oil cavitation flow:
a – without saturation; *b* – argon; *c* – nitrogen; *d* – nitrogen & argon

This allowed directly at the entrance to the cavitator to obtain a two-phase flow with different depths of saturation.

It was also observed that the luminescence in the two-phase medium forms a "shot" that occurred earlier in the gaseous medium at 2 bar (Fig. 7). It is established that in the gas phase we can obtain this luminescence effect. Thus it is possible to draw an analogy between the jump of the seal. It follows that the effect of hydrodynamic luminescence can also be called "gas-dynamic luminescence", or biphasic luminescence. The advantages of the following are lower energy costs for obtaining luminescence for technological processes.

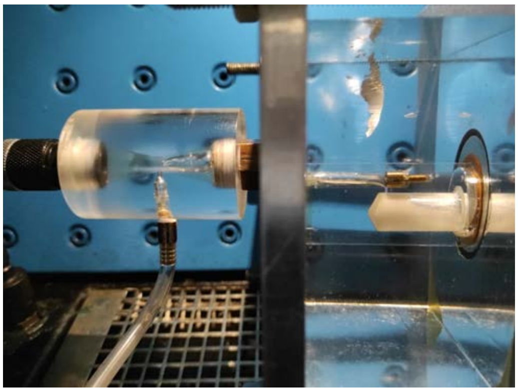


Fig. 7. Emission of light in the two-phase cavitation flow of mineral oil (gas-dynamic luminescence)

Based on the results of elaboration and analysis of the conducted experimental researches, a conceptual model of the stages of origin and development of the cavitation process and accompanying effects is constructed (Fig. 8).

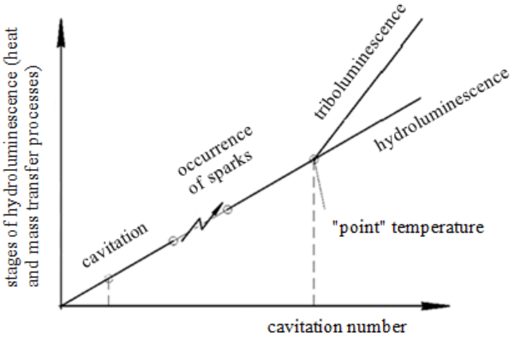


Fig. 8. Occurrence of cavitation and accompanying physical processes in the fluid flow

According to our observations, with increasing flow velocity in the area of narrowing, first there is cavitation, then, with a further increase in flow velocity, single sparks begin to appear, and from a certain point there is a "shot". and there is a stable glow. When reaching the "point temperature" and in the presence of parts of materials with cavitation emission, there is an increase in the intensity of the glow due to triboluminescence, in the absence of suitable materials, the process is less intense.

The study of the nature of hydrodynamic luminescence can be compared to fire: first it is a weak spark, then a flickering flame, and then a powerful flame endowed with speed and power.

It can be assumed that the process of cavitation in the flow of mineral oil in narrow slits can cause electrical resistance of the oil base and channels, as well as lead to burnout of corrective additives to the oil. The main source of light radiation is the emission of gas into vapor bubbles, such as hydrogen. For example, water present in the working fluid under the action of cavitation can decompose into hydrogen and oxygen, which then ignite with a discharge.

The conducted researches allowed to reveal the cavitation zones arising in the cavitator. Cavitation areas were identified with the help of high-speed video recording and the mechanism of its development was investigated. In addition, the visualization characteristics of the closed volume to some extent clarify the existing ideas about the behavior of the liquid in the nozzle.

The results of the study are valid for Newtonian fluids, which include oil used during the experiment. For non-Newtonian fluids, the cavitation process can be more complex, requiring further research. In addition, the purpose of further research is a detailed study of the influence of the phenomenon of hydroluminescence on cavitation processes[20–24].

The cavitators that have been studied in this article can work with a variety of liquids. Some of them are sensitive to the effects of cavitation, which can change their physical, chemical and rheological properties. Thus, the study of the conditions of cavitation phenomena and their development will allow to choose rational modes of operation of the cavitator: the diameter of the fittings, the pressure drop, flow rate and temperature of the working fluid.

The use of hydrodynamic cavitation with hydrodynamic luminescence to obtain energy under certain conditions is rational, which is due to the compactness and cheapness of the installation as a whole. Cavitation energy storage can be one of the most innovative and effective ways to achieve high energy density today.

Conclusions. An experimental stand and a model of a hydrodynamic cavitator were developed and a series of experiments were conducted. The studies allowed to study the cavitation in the throttle element and below the hole. Observations have shown that luminescence is observed under certain conditions. Its intensity is determined by a number of factors, one of which is the correlation between the intensity of luminescence and gas saturation.

A review of studies has shown that light radiation depends on the rheological properties of the liquid. More intense where there is less viscosity. The gas-oil mixture has a significant effect, more radiation was observed. The concentration of dissolved noble gas (Ar) Argon, (N) Nitrogen, in hydrodynamic luminescence significantly affects the light radiation that occurs during cavitation at the edge of the choke.

Thus, during hydroluminescence, excitation of the added inert gases occurs first of all, which then, as a result of second-order Frank-Hertz shocks, transmit the perturbation to the oil molecules. Increases as the ionized potential (perturbation potential) decreases. Based on the work performed, it can be concluded that the cause of hydrodynamic luminescence is the friction of the liquid against the walls of the channel and the light radiation of the double electric layers. Therefore, the cause of hydrodynamic luminescence is a local increase in electric field strength, which occurs when the electroneutrality inside the cavity.

Experimental studies have shown that the temperature of the working fluid significantly affects the flow characteristics of the choke. The result of heating is a decrease in the viscosity of the working fluid, which leads to an increase in the Reynolds number and, accordingly, the flow rate. The obtained experimental data were approximated to the possibility of using a mathematical model of a hydrodynamic cavitation generator and allowed to take into account the properties of the working fluid.

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