
<https://doi.org/10.15407/ujpe71.6.495>

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PULSATING EVAPORATION OF EMULSION DROPLETS UNDER THE ACTION OF A HIGH-FREQUENCY ELECTRIC DISCHARGE

The pulsations of droplet size in diesel-water emulsions under the action of a high-frequency electric discharge have been studied using high-speed video recording. The discharge leads to the dispersion of emulsion droplets with a high water content, in contrast to droplets of pure combustible liquids. By processing video recordings of the evaporation process, the time dependence of the projection-equivalent droplet size was determined. The results of this study can be used in further investigations of the spray combustion of emulsion droplets when an additional high-frequency electric discharge is applied at the atomization stage.

Keywords: diesel-water emulsions, droplets, electric streamer, pulsations, period, microexplosion.

1. Introduction

One of the key tasks in modern thermal power engineering is to minimize harmful pollutant ejection generated during the combustion of hydrocarbon fuels [1]. Promising approaches to solving this problem include the introduction of water into the fuel composition. The presence of water in the fuel mixture helps to reduce the flame temperature, which, in turn, allows the formation of nitrogen oxides NO_x and carbon monoxide CO to be significantly reduced. In addition, water affects the rheological characteristics of the fuel by improving the conditions for its dispersion during combustion. Of particular interest is the possibility of using emulsion fuels (“oil in water” and “water in oil”) in diesel engines [2].

Citation: Chernenko O.S., Ivanov M.O., Tymofienko K.V. Pulsating evaporation of emulsion droplets under the action of a high-frequency electric discharge. *Ukr. J. Phys.* **71**, No. 6, 495 (2026). <https://doi.org/10.15407/ujpe71.6.495>.
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ISSN 2071-0194. Ukr. J. Phys. 2026. Vol. 71, No. 6

Under certain thermodynamic conditions, during the combustion of emulsion droplets in the combustion chamber, a micro-explosion phenomenon can occur. This is an explosive boiling process in which a droplet disintegrates into smaller ones. Due to the increase in the total contact surface between the fuel and the oxidant, the combustion process becomes intensified, which has a positive effect on its efficiency.

2. Analysis of Literature

Data. Formulation of the Problem

The formation of an emulsion assumes the presence of at least two mutually insoluble liquids, e.g., water and liquid fuel. Depending on the composition, two main types of emulsions can be formed after the dispersion of a mixture of immiscible liquids: “oil in water” (O/W), when the fuel phase is dispersed in the water phase, and “water in oil” (W/O), when, on the contrary, water is distributed in the fuel phase [3]. Alcohols can be an alternative to water in emulsions with diesel fuels [4].

Active research is being conducted on emulsions with bio-oils [5], waste oils [6], and fuel oils [7]. As a

rule, micro-explosions occur in systems with a noticeable difference between the physico-chemical properties of the components [8]. Among the advantages of emulsion fuels is the possibility of using components obtained from waste oil and “contaminated” water containing, e.g., petrochemicals.

As the temperature of the medium increases, three characteristic modes of thermal action are observed for emulsion fuel droplets [9–11]: evaporation, puffing, and micro-explosion. In the first mode, a droplet gradually decreases, preserving the integrity of its surface. During puffing, a local curvature is formed at the droplet surface, which quickly collapses, generating small droplets of liquid fuel. This is a result of the boiling of water droplets inside the emulsion droplet. With the further intensification of heating, numerous steam bubbles are formed simultaneously, which brings about an explosive expansion of the droplet, i.e., its micro-explosion.

As was shown in Ref. [12], when emulsions were heated in a furnace, a gradual increase in the droplet size d and the appearance of a liquid jet were observed. The latter emerged through the droplet surface owing to the local pressure increase caused by the rupture of steam bubbles near the outer layer. This process created a channel for steam ejection under high pressure, which contributed to the rupture of the liquid shell into numerous fragments. The characteristic diameter of secondary droplets after the micro-explosion, as a rule, did not exceed $200\ \mu\text{m}$.

To determine the conditions under which emulsion droplets undergo micro-explosion, a number of analytical approaches have been proposed in the literature [9]:

- 1) the analysis of the conditions under which the critical nucleation temperature, a temperature close to the boiling point of one of the emulsion components at the water-in-oil (W/O) phase interface, is reached;
- 2) the estimation of how much the pressure inside the vapor bubble exceeds the sum of the external pressure and surface tension forces at the interface;
- 3) the experimental determination of the critical radius of the vapor bubble.

In Ref. [13], the results of high-speed video recording of the combustion of an emulsion droplet with a water content of about 50% were presented. It was found that the ignition temperature of the oil phase exceeds the boiling temperature of water, so the microexplosion is initiated by heating water globules

inside the droplet. The behavior of such systems is essentially different from that observed during the combustion of “pure” fuel. Namely, the classical d^2 -law is observed for a homogeneous oil droplet. At the same time, in the case of an emulsion, a local flash is registered near the surface. Then, after a micro-explosion, gas-phase combustion occurs throughout the entire volume around the droplet. It was shown that the furnace temperature had a weak effect on the combustion duration of emulsion droplets, but it influenced the rate of their heating and the ignition delay. Therefore, the possibility of limiting the preheating of the combustion chamber to temperatures sufficient for the ignition to start, but lower than the critical ones, was emphasized.

Besides studying the behavior of individual droplets in the emulsion, considerable attention is paid to experiments under natural conditions that simulate the combustion of a spray flame of emulsion fuel. During such studies, two main factors are identified that can suppress the combustion process when fuels with an increased water content are used. First, an intensive cooling of the flame is observed, which is caused by heat consumption for the evaporation and heating of the water phase. Second, if stoichiometric combustion conditions are obeyed, the oxygen fraction in the mixture of reagents decreases as the water content increases, which limits the oxidation intensity.

In Ref. [14], a schematic diagram of the flammability of vapors of higher hydrocarbons mixed with air and water vapor at atmospheric pressure was presented. It was shown that as the fraction of water vapor increases, the range of hydrocarbon concentrations at which ignition is possible becomes narrower. At the same time, according to theoretical calculations, even mixtures containing up to 75 wt% water can remain flammable under stoichiometric air conditions. The growth of the oxygen content in the gas blow during the combustion of emulsions with a water content of 50 wt% increases the efficiency of the process from 45% to 78%. This can be explained by the absence of nitrogen, which is an inert component under normal conditions.

The concentration of water in the fuel, as well as the oxygen content in the oxidizer, substantially affects the level of formation of nitrogen oxides NO_x . In particular, during the combustion of pure fuel oil in pure oxygen, the concentration of NO_x reached a

value of about 760 ppm, whereas this parameter decreased to 430, 210, and 100 ppm when emulsions with water contents of 25, 50, and 75 wt%, respectively, were used. Such a reduction is directly related to the decrease in flame temperature and confirms the positive effect of the water component on the ecological characteristics of the combustion process.

Experimental data on the combustion of oil/water emulsions with water contents of 10 and 20 wt% in a diesel engine [15] also showed that compared to conventional diesel fuel (DF), a decrease in the combustion intensity (lower flame brightness), a reduction in the formation of nitrogen oxides NO_x and smoke, and a shorter duration of the combustion process are observed.

One of the promising methods for controlling the combustion process of gaseous, liquid, and dispersed fuel systems is the application of electrical discharges of various types [16–18]. In Ref. [19], the evaporation of liquid and emulsion droplets in air under the thermal influence of a high-frequency electrical discharge was studied. For emulsions with a water content of up to 50%, pulsations of the geometric sizes of the droplets were registered after the heating stage. Namely, the diameter of a droplet varied periodically around a certain average value, which gradually decreased as the evaporation duration increased. Such pulsations are explained by the evaporation of water globules inside the droplet and the formation of steam bubbles, which induce periodic oscillations of the droplet volume. The loss of emulsion mass under the action of electric discharge occurs mainly due to liquid ejections during puffing, as a result of a local rupture of the droplet shell.

Therefore, the study of the combustion and evaporation processes of emulsion fuels remains a challenging task for modern energy science. The aim of this work was to experimentally study the regularities of the evaporation of water-fuel emulsion droplets with various water contents under the influence of a high-frequency electric discharge.

3. Materials and Methods

The experimental objects were two-phase emulsion systems of the “diesel–water” type, which were prepared without surfactants. The water fraction varied from 0 to 80 vol%, with an increment of 10 vol%. For mixing and emulsification, an ultrasonic disperser UZDN-1 operating at a frequency of 22 kHz was

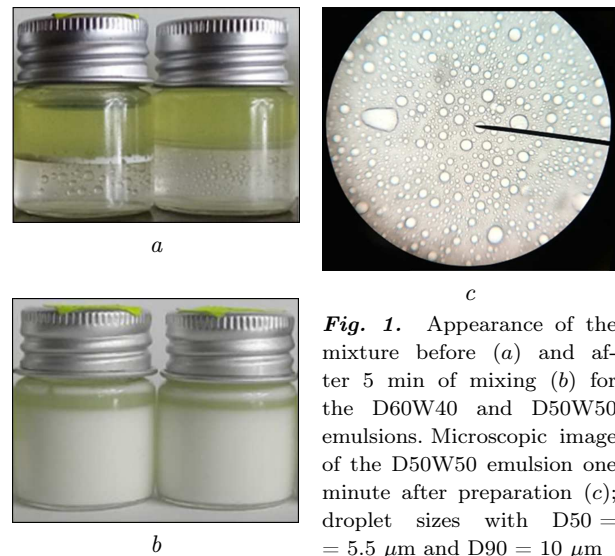


Fig. 1. Appearance of the mixture before (a) and after 5 min of mixing (b) for the D60W40 and D50W50 emulsions. Microscopic image of the D50W50 emulsion one minute after preparation (c); droplet sizes with D50 = 5.5 μm and D90 = 10 μm

applied. The device probe was immersed in a glass container with a volume of 10 ml (Fig. 1, a), into which the system components had been previously placed. The treatment duration was approximately one minute.

As a result of the ultrasound action, the mixture of two mutually insoluble liquids was transformed into a visually homogeneous white suspension throughout the volume (Fig. 1, b); this mixture was later used for the study. The most effective mixing of the components took place at water fractions of 40–60 vol%, which was verified by the bottle test [20]: a freshly prepared emulsion is left undisturbed in a small bottle, and either the time until the appearance of visible phase separation or the percentage of separated water over time is recorded. For the indicated emulsions, the separation time was longer than 3 h. For emulsions with low water contents or pure diesel, the separation became noticeable after 10 min. The same method was used to study the stability of aqueous emulsions with waste lubricant [18]. The half-stratification time for emulsions with water fractions up to 30% was 750–1200 s.

The method of emulsion preparation also affects the separation time [20]: the smaller the droplets, the more stable the emulsion. Therefore, the application of an ultrasonic disperser was a good solution.

Immediately after emulsion preparation, several droplets were taken with a pipette and placed on a glass slide for optical microscopy (Fig. 1, c). The di-

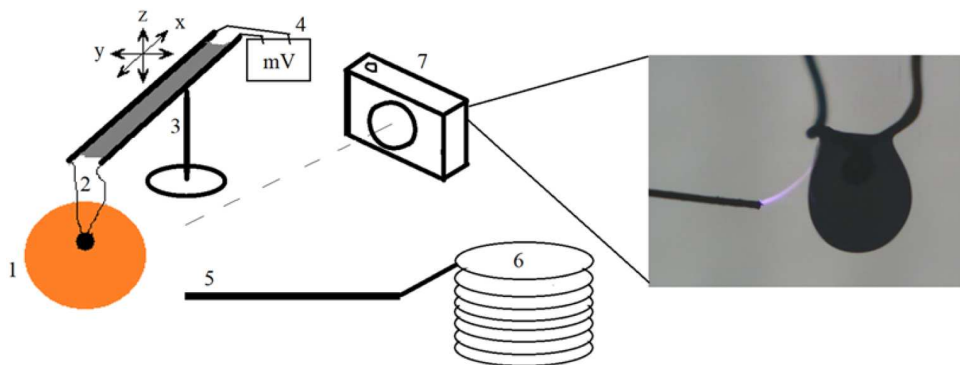


Fig. 2. Schematic diagram of the experimental setup: emulsion droplet (1), thermocouple (2), spatially adjustable mount on a stand (3), millivoltmeter (4), electrode (5), Tesla generator coil (6), camera (7)

ameter of the needle in the micrograph is $7.5 \mu\text{m}$. Transparent spherical particles of various diameters are clearly visible in the micrograph. The average size of the droplets varied depending on the emulsion composition; the smallest particles were observed in emulsions with water contents of 40–60%. The state of the emulsion 5 min after preparation is shown in Fig. 1, *b*. The main amount of water in the emulsion is contained in droplets with the sizes $d > 2 \mu\text{m}$, which is typical of ultrasonic treatment at 22 kHz without surfactants.

In Ref. [21], using the example of the D95W5 emulsion, it was shown that its destabilization began 10 s after its formation, and the average diameter of water droplets increased from 0.41 to $15.38 \mu\text{m}$. Since no surfactant was introduced into the system, the repulsive forces between the droplets were insufficient for stabilization, which caused the droplets to coalesce. This process occurred due to a gradual decrease in the thickness of the interfacial film separating the droplets, which took place under the action of Van der Waals forces. Within 25 s, droplets large enough to precipitate were formed.

In our study (Fig. 1, *c*), we also observed the formation of noticeably larger droplets when the specimen was sampled and applied to a glass slide. At the same time, a substantial amount of fine (micron-sized) particles remained in the specimen. The complete stratification of the system became apparent already one day after its preparation. Therefore, we assumed that within 5 min after the emulsion preparation, when the droplets were being burned, the emulsion composition remained unchanged.

As a rule, the fuel transit time from the moment of mixture formation to its injection into the combustion

chamber in the fuel supply system of a single-cylinder diesel engine is about 2–5 s. In the case of engines operating on water-fuel emulsions, the formation of a mixture of water with diesel fuel is carried out by means of ultrasonic emulsification directly in front of the combustion chamber [22]. Therefore, as noted in Ref. [22], the processes of emulsion destabilization are not taken into account in such systems because, in the absence of a surfactant, the emulsion is prepared for immediate use in the combustion process rather than for storage.

4. Experimental Setup

For the studies, a thin thermocouple of the XA type with a junction 0.5 mm in diameter was used. It was located in an air environment at room temperature. A droplet of emulsion, which was prepared immediately before the experiment, was applied to the thermocouple junction (Fig. 2). The wetting process was carried out in such a way that the junction was inside the droplet volume.

A copper electrode about $150 \mu\text{m}$ in diameter and connected to a Tesla mini-generator with a supply voltage of 9–12 V was installed at a certain distance from the droplet. At a certain moment, the coil power was turned on, and a high-frequency electric discharge was applied to the droplet.

To evaluate the thermal power of the discharge, the experiments were previously carried out with separate water or ethanol droplets, and their evaporation under the action of the discharge was observed. Assuming that all thermal energy from the discharge is transferred to the droplet (the contribution of heat exchange was less than 10% of the incoming power P), then the time dependence of the droplet volume

Table 1. Electrical conductivity of emulsions (in ppm)

Pure	Inverse		Close contents			Direct		Pure
D100	D90W10	D80W20	D60W40	D50W50	D40W60	D20W80	D10W90	W100
0	40	65	100	150	200	370	440	500

V can be described by the equation

$$L\rho \frac{dV}{dt} = P,$$

where L is the specific heat of vaporization, and ρ is the liquid density. According to this equation, the droplet volume should decrease linearly with time. In this case, the calculated values of the discharge power P ranged from 0.13 to 0.25 W, depending on the distance between the electrode and the droplet [19].

As the discharge approached the droplet, the thermal heating power first increased and then decreased. The discharge shape was that of a cylinder about 1.5–2 mm in length. When the droplet moved away from the discharge zone, the heat transfer efficiency decreased. If the droplet approached the electrode at a distance less than the discharge length in the quiet state, the real channel length became shorter. As a result, the heat release in the plasma channel decreased, which accordingly reduced the heat transfer to the droplet.

The electric discharge power was also evaluated according to its thermal effect on paraffin. For this purpose, a solid fragment of paraffin previously kept at room temperature was used. The mass of the specimen was determined before the discharge action and after a certain time interval, during which some part of the substance melted and flowed down from the surface of the solid piece. The mass of the melted paraffin was used to calculate the thermal discharge power, which was found to be approximately 0.13 W.

To analyze the behavior of the emulsion droplet, video recording was performed at a speed of 400 frames per second. The recording was performed using a Nikon J1 camera mounted on an optical bench together with a lens. An LED light source was located in the background; it provided uniform illumination and a contrast image of the droplet shape. The resulting video materials were subjected to frame-by-frame analysis. For every frame, the contour of

the droplet surface (excluding the thermocouple electrodes) and the equivalent projection diameter were determined. The latter was used for further calculations of the dynamics of the droplet shape variations.

5. Research Results

The evaporation of the droplets of pure liquids (diesel fuel and water) under the action of an electric discharge occurred in accordance with the classical d^2 -law. In this case, the internal structure of the droplets remained homogeneous, without noticeable features or zones of phase separation.

Mixing diesel fuel with water, depending on their ratio, resulted in the formation of a direct or inverse emulsion. The direct emulsion (O/W) is a system of the “oil in water” type, where water is the dispersion medium, and fuel forms the dispersed phase. And vice versa, the inverse emulsion (W/O) is a system of the “water in oil” type, where fuel is the dispersion medium, and water is the dispersed phase.

The emulsion type was determined using the electrical conductivity method. High values of electrical conductivity indicate the presence of a polar medium, i.e., the emulsion belongs to the O/W type. In contrast, low electrical conductivity values correspond to W/O emulsions. A TDS meter, which provided the measurement results in ppm units, was used to quantitatively evaluate the electrical conductivity. The results obtained immediately after the emulsion preparation are given in Table 1. A certain regularity can be observed: if the water fraction was small, the electrical conductivity was insignificant, which confirms the formation of an inverse emulsion; for large water fractions, the electrical conductivity increased, indicating the formation of direct emulsion.

In Fig. 3, the dependencies of the emulsion droplet diameter on the duration of electric discharge action are shown for various water volume fractions. In addition to high-frequency pulsations of the droplet size, a qualitative difference between the behavior of direct

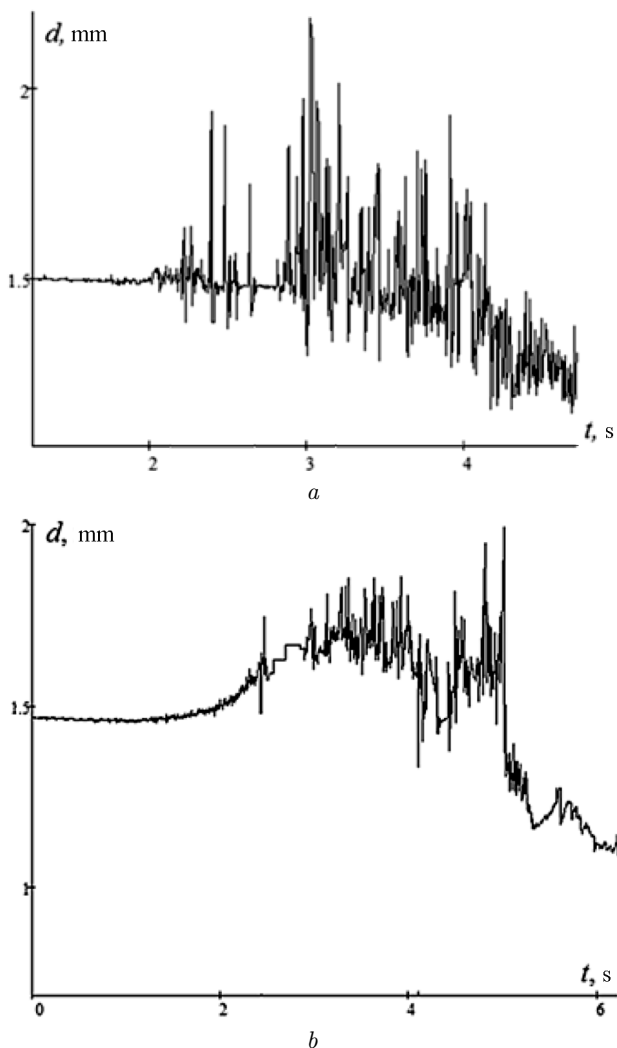


Fig. 3. Characteristic time dependencies of the emulsion droplet size for the D70W30 (a) and D30W70 (b) emulsions

and inverse emulsions was revealed. Inverse emulsions are characterized by evaporation that obeys the d^2 -law, whereas direct emulsions exhibit a noticeable increase in droplet size at the initial stage, followed by a drastic decrease in the droplet diameter.

A droplet of the inverse D80W20 emulsion was characterized by the ejection of tiny particles less than $100 \mu\text{m}$ in size, which instantly burned out and formed a smoke cloud (Fig. 4, a). The dependence of the droplet diameter on time, $d(t)$, corresponds to the d^2 -law, but numerous pulsations are also observed so that this law is somewhat “blurred”. Larger drops, exceeding $100 \mu\text{m}$ in diameter, were rarely formed. The-

refore, pulsations and ejections of the substance only slightly affected the total evaporation rate.

For a droplet of the D70W30 composition, the pulsation frequency changed during the evaporation process. At the initial stage after heating, smaller droplets were ejected from the droplet surface with a period of about 20 ms. At the next stage, the pulsations were associated with the formation of vapor bubbles that expanded near the droplet surface; then they burst (Fig. 4, b). As the droplet diameter diminished, the pulsation period became equal to 25–30 ms.

For systems with close water and fuel fractions, in particular, for the D60W40 emulsion, intense pulsations with a period of 13–20 ms were observed; they were associated with the expansion of vapor bubbles in the droplet. The diameter changed by about $\pm 25\%$ in this case. After the bubbles had burst, larger droplets with a diameter of up to $200 \mu\text{m}$ were ejected.

During the evaporation of emulsion droplets, vapor bubbles were formed in the bulk, and they moved along circulatory trajectories. The electric discharge mainly acted on the junction in the upper part of the droplet, forcing the bubbles to move away from this region. For inverse emulsions, the number of bubbles was small, and their growth was slow, so the droplet diameter increased gradually. As a result, the ejection of the substance occurred mainly due to the rupture of one large bubble.

For emulsions with close water and fuel contents, a simultaneous growth of several vapor bubbles was observed. In the zone near the thermocouple junction, where the temperature was higher, the number of bubbles increased (Fig. 4, c). At the electrode input, these bubbles were intensively heated, which led to micro-ejections of small droplets. Accordingly, the pulsation period in this zone decreased to 7.5–12.5 ms.

Emulsions with higher water contents (70–90%) are direct O/W emulsions. The main feature of their evaporation is the formation of a foam-like surface structure. In the upper part of the droplet, near the heated junction, steam bubbles were intensively formed (Fig. 4, d). For some time, they were retained on the surface; then, they burst and formed small droplets. In this case, the total diameter of the droplet could increase by approximately 20% (Fig. 3, b).

For droplets of the D30W70 composition, the number and size of steam bubbles were smaller than those

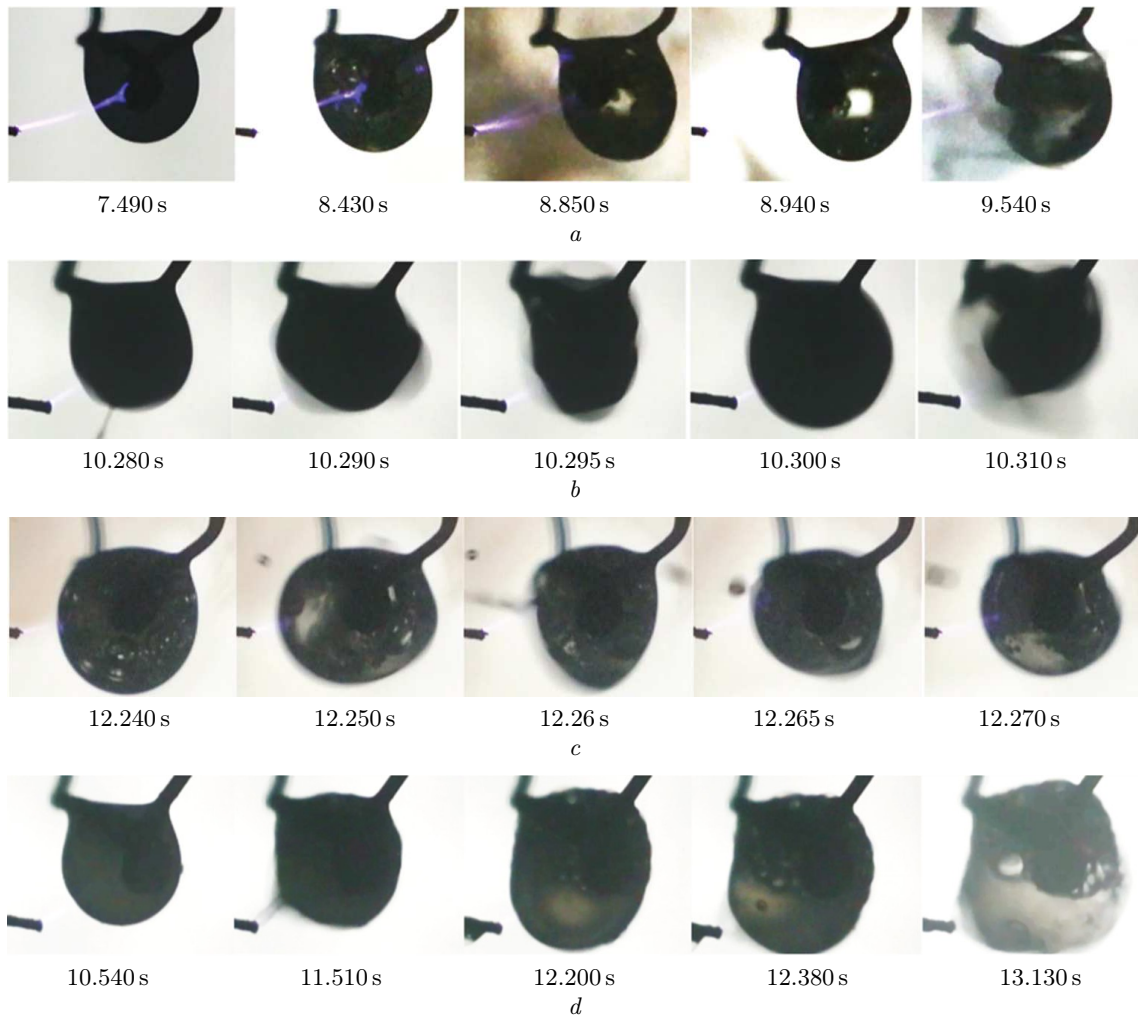


Fig. 4. Examples of the emulsion droplet shapes during pulsation for various emulsions: D80W20 (a), D70W30 (b), D50W50 (c), and D30W70 (d)

in the D20W80 system, and the period of pulsations associated with the detachment of small droplets ($<100 \mu\text{m}$) was 10–15 ms.

In the case of the D10W90 emulsion, the vaporization process occurred in the droplet bulk. The video recordings clearly demonstrated the movement of steam bubbles along closed trajectories, whereas the amplitude of the diameter pulsations remained minimal.

6. Discussion

In Fig. 5, experimental data obtained for the dependence of the pulsation period of the emulsion droplet size on the water fraction are presented. In general,

the pulsation period is mainly within the interval of 10–20 ms. Inverse emulsions are characterized by small fluctuations of the droplet diameter, whereas the droplet shape remains close to spherical. Such droplets demonstrate successive micro-ejections of liquid giving rise to the formation of small droplets with diameters not exceeding $100 \mu\text{m}$.

Direct emulsions also demonstrate ejections of small droplets. However, in addition, a foam-like structure is formed from vapor bubbles that appear near the droplet surface. This phenomenon leads to an increase in the average droplet diameter by approximately 25%. Afterward, the foam gradually collapses due to the bursting of the bubbles.

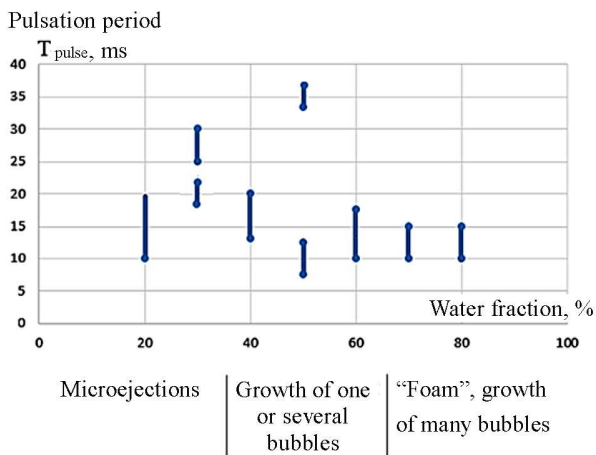


Fig. 5. Dependence of the characteristic period of emulsion droplet size pulsations on water content

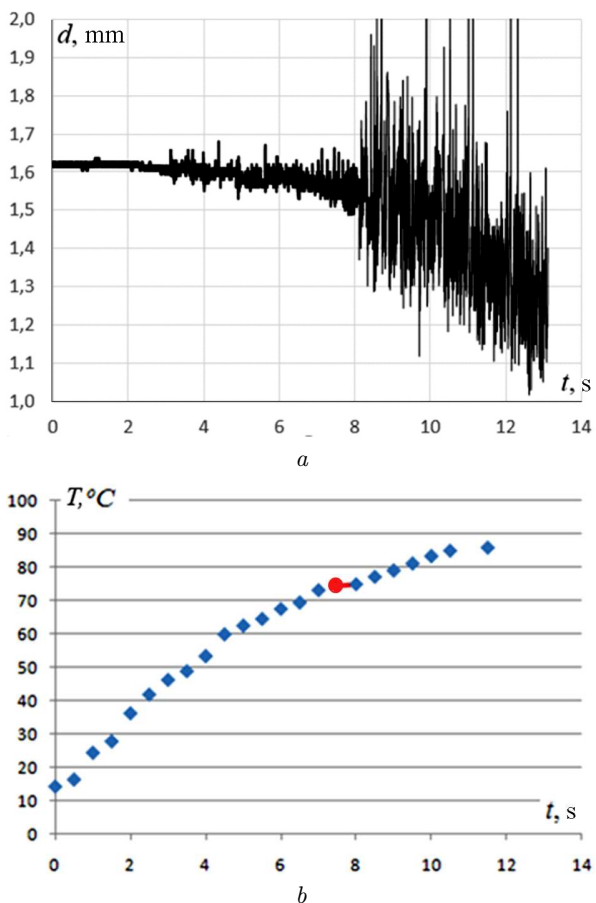


Fig. 6. Temporal variations of the size d of a D50W50 emulsion droplet with an initial diameter of 1.62 mm (a) and the time dependence of the temperature T of the thermocouple on which this droplet was located (b)

Such behavior can be explained by a reduction in the surface tension of the emulsion components upon heating. In particular, the surface tension of diesel fuel (DF) is 29 mN/m at 20 °C, and that of water is 73 mN/m; at 100 °C, the corresponding values are 20 and 59 mN/m, respectively. Since the surface tension of DF is lower than that of water, vapor is mainly formed at the boundaries of fuel globules, which act as boiling nuclei.

Emulsions with close water and fuel fractions are characterized by pronounced pulsations, accompanied by chaotic deformations of the droplet shape. This occurs due to the growth of several steam bubbles inside the droplet, the formation of steam buildup on the surface, and the subsequent bursting of the bubbles.

According to the experimental results, the time of droplet heating before the onset of pulsations varied from 1 to 11 s, depending on several factors.

1. The droplet size. The diameters of the examined droplets varied within the interval of 1.4–2.6 mm. Even an insignificant increase in size from 1.5 to 1.9 mm led to an increase in the heating time from 2.5 to 6 s.

2. The emulsion composition. Since the specific heat capacity of water is approximately twice that of diesel fuel, emulsions with a smaller water fraction warm up faster.

3. The initial thermocouple temperature. During serial experiments, the thermocouple remained partially heated after each measurement. This circumstance reduced the heating time of subsequent droplets because the duration of high-speed video recording was limited to five seconds, and several consecutive recordings were performed for each series.

In Fig. 6, the diameter variations of a droplet of D50W50 emulsion with an initial diameter of 1.6 mm (a) and the time dependence of the temperature of the thermocouple on which the droplet, heated by an electric discharge, was placed (b) are shown. The circle in panel b corresponds to the moment when micro-explosions appeared on the surface. It is worth noting that the droplet temperature at this moment was lower than the boiling point of water. Assuming that the condition of pressure equilibrium in a vapor bubble is satisfied, we can estimate that the equilibrium radius of such a bubble is about 2 μ m at 75 °C.

7. Conclusions

The analysis of experimental observations allowed us to form a holistic understanding of the interaction between an electric discharge and an emulsion droplet. During the experiment, the electric streamer passes through the volume of the droplet and reaches the thermocouple junction, which acts as a receiver of thermal energy.

Under the influence of the discharge, two time stages of the process are clearly distinguished: the phase of inertial heating, when the droplet temperature gradually increases without noticeable structural changes, and the pulsation mode, when the droplet size periodically changes with a certain frequency around an average value, which gradually decreases due to evaporation.

Since the discharge duration is short, the streamer does not have enough time to heat the entire droplet volume uniformly. The most intensive heating is observed in the regions located near the streamer trajectory and the thermocouple junction. Under the action of the electric discharge, emulsions with high water contents show a tendency to disperse, whereas pure combustible liquids do not exhibit this behavior. Since the thermocouple junction is heated faster than the liquid, vapor bubbles form mainly on its surface, where locally intensive evaporation is observed. At the beginning of pulsations, these bubbles expand from the junction toward the droplet surface, mainly in the zone close to the electric streamer. This effect explains why the experimental values of the warm-up time turned out to be shorter than the calculated ones, and also why the observed pulsation period was approximately half of the theoretically expected one [19].

For inverse emulsions (water content <30%), the growth of a single vapor bubble, the size of which is comparable to the diameter of the droplet itself, is typical. In systems with close component contents (40–60%), the pulsations are caused by the simultaneous expansion of several bubbles. In turn, direct emulsions (water fraction >70%) are characterized by the formation of a foamy structure consisting of vapor bubbles surrounded by molecular shells of diesel fuel; these bubbles can grow and burst almost simultaneously.

The loss of substance in emulsion droplets under the influence of an electric discharge mainly occurs

due to micro-explosions and microdroplet ejections at the moment of bursting. According to the measurement results, the period of droplet size pulsations under the action of an electric discharge was on average 10–25 ms.

1. X. Pei, P. Guida, K.M. AlAhmadi, I.A. Al Ghamdi, S. Saxena, W.L. Roberts. Cenosphere formation of heavy fuel oil/water emulsion combustion in a swirling flame. *Fuel Process. Technol.* **216**, 106800 (2021).
2. Shuhn-Shyurng Hou, F.M. Rizal, Ta-Hui Lin, Tzu-Yueh Yang, Hou-Peng Wan. Microexplosion and ignition of droplets of fuel oil/bio-oil (derived from lauan wood) blends. *Fuel* **113**, 31 (2013).
3. I. Park, Oh. Jungmo. Study on the characteristics of performance, combustion, and emissions for a diesel water emulsion fuel on a combustion visualization engine and a commercial diesel engine. *Fuel* **311**, 122520 (2022).
4. Chi-Yao Chao, Hsuan-Wei Tsai, Kuo-Long Pan, Chih-Wei Hsieh. On the microexplosion mechanisms of burning droplets blended with biodiesel and alcohol. *Combust. Flame* **205**, 397 (2019).
5. A. Hoxie, R. Schoo, J. Braden. Microexplosive combustion behavior of blended soybean oil and butanol droplets. *Fuel* **120**, 22 (2014).
6. E. Mura, R. Calabria, V. Califano, P. Massoli, J. Bellettre. Emulsion droplet micro-explosion: Analysis of two experimental approaches. *Exper. Therm. Fluid Sci.* **56**, 69 (2014).
7. Shuhn-Shyurng Hou, F.M. Rizal, Ta-Hui Lin, Tzu-Yueh Yang, Hou-Peng Wan. Microexplosion and ignition of droplets of fuel oil/bio-oil (derived from lauan wood) blends. *Fuel* **113**, 31 (2013).
8. Weiwei Shang, Shouyin Yang, Tiemin Xuan, Zhixia He, Jiawei Cao. Experimental studies on combustion and microexplosion characteristics of nalkane droplets. *Energy Fuels* **34**, 16613 (2020).
9. D.V. Antonov, R.M. Fedorenko, P.A. Strizhak. Micro-explosion phenomenon: Conditions and benefits. *Energies* **15**, 7670 (2022).
10. P. Strizhak, M. V. Piskunov, R.S. Volkov, J.C. Legros. Evaporation, boiling and explosive breakup of oil–water emulsion drops under intense radiant heating. *Chem. Engin. Res. Design* **127**, 72 (2017).
11. J. Won, S.W. Baek, H. Kim. Autoignition and combustion behavior of emulsion droplet under elevated temperature and pressure conditions. *Energy* **163**, 800 (2018).
12. M.M. Avulapati, T. Megaritis, J. Xia, L. Ganippa. Experimental understanding on the dynamics of micro-explosion and puffing in ternary emulsion droplets. *Fuel* **239**, 1284 (2019).
13. G.V. Kuznetsov, K.Yu. Vershinina, T.R. Valiullin, P.A. Strizhak. Differences in ignition and combustion characteristics of waste-derived oil-water emulsions and coal-water slurries containing petrochemicals. *Fuel Process. Technol.* **179**, 407 (2018).

14. C. Gabera, P. Wachter, M. Demuth, C. Hochenau. Experimental investigation and demonstration of pilot-scale combustion of oil-water emulsions and coal-water slurry with pronounced water contents at elevated temperatures with the use of pure oxygen. *Fuel* **282**, 118692 (2020).
15. D.V. Antonov, G.V. Kuznetsov, P.A. Strizhak. Comparison of the characteristics of micro-explosion and ignition of two-fluid water-based droplets, emulsions and suspensions, moving in the high-temperature oxidizer medium. *Acta Astronautica* **160**, 258 (2019).
16. Shuai Huang, Tie Li, Xinran Wang, Run Chen, Rundai Yang, Zhonghua Qian. Effects of various discharge strategies on ignition and combustion of lean natural gas mixture under the static and turbulent conditions. *Exper. Therm. Fluid Sci.* **133**, 110581 (2022).
17. N.A. Bulychev. Electric discharge in liquids under the effect of vibration. *Int. J. Recent Technol. Engin.* **8**, 68 (2019).
18. V.H. Shevchuk, A.V. Nymych, O.S. Chernenko, O.Ye. Sydorov, M.O. Ivanov. Use of aqueous emulsions of waste motor oils as a highly efficient fuel. *Zbirn. Nauk. Prats Vysk. Akad. (Odesa)* **2**, 139 (2023) (in Ukrainian).
19. O.S. Chernenko, K.V. Tymofiienko, M.O. Ivanov. Evaporation of combustible liquid droplets in an electric discharge. *Fiz. Aerodysp. Syst.* **61**, 212 (2023) (in Ukrainian).
20. A. Husain, A.A. Adewunmi, M. Mahmoud, M. Kamal. Stability of diesel/water emulsions: experimental and modeling investigations. *J. Energy Res. Technol.* **143**, No. 11, 1 (2021).
21. A.M. Ithnin, W.J. Yahya, M.A. Ahmad, N.A. Ramlan, H. Abdul Kadir, N.A.C. Sidik, T. Koga. Emulsifier-free water-in-diesel emulsion fuel: Its stability behaviour, engine performance and exhaust emission. *Fuel* **215**, 454 (2018).
22. C. Mata, V. Rojas-Reinoso, J.A. Soriano. Experimental determination and modelling of fuel rate of injection: A review. *Fuel* **343**, 127895 (2023).

Received 29.10.25.

Translated from Ukrainian by O.I. Voitenko

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ПУЛЬСАЦІЙНЕ ВИПАРОВУВАННЯ КРАПЕЛЬ ЕМУЛЬСІЇ ПІД ДІЄЮ ВИСОКОЧАСТОТНОГО ЕЛЕКТРИЧНОГО РОЗРЯДУ

Методом швидкісної відеозйомки досліджувалися пульсації розміру крапель емульсій дизель-вода під дією високочастотного електричного розряду, що приводить до диспергування крапель емульсій з великим вмістом води, на відміну від крапель однокомпонентних горючих рідин. Шляхом обробки відеофайлів процесу випаровування визначалася часова залежність проекційного еквівалентного розміру крапель. Результати цієї роботи можуть бути використані в подальших дослідженнях розпилення та горіння крапель емульсії із застосуванням додаткового високочастотного електричного розряду на стадії атомізації.

Ключові слова: емульсії, дизель-вода, краплі, електричний стример, пульсації, період, мікрровибух.