Acoustic and heat energy emission of electrohydraulic spark discharge

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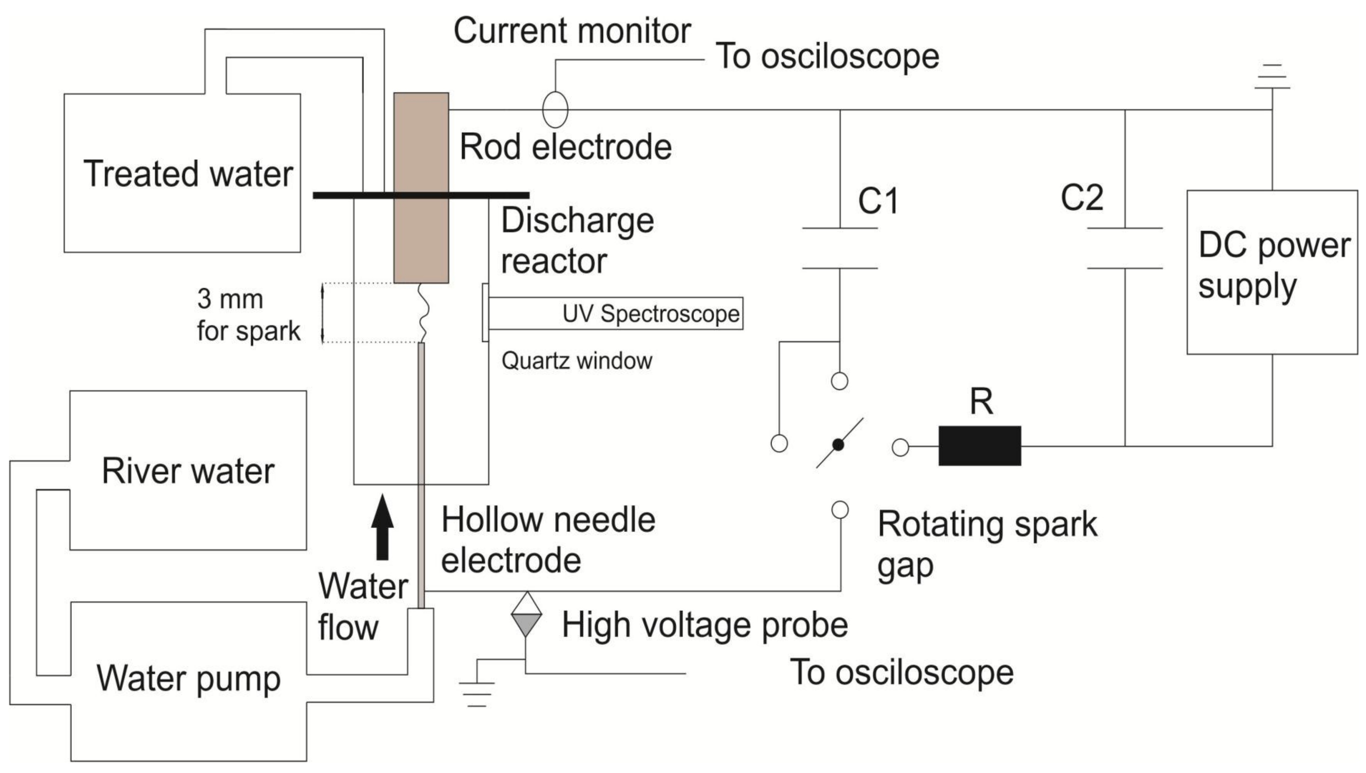
Motivation

- The recent focus of electrohydraulic discharges is on bacteria and microorganism inactivation,
- Spark discharge in water can efficiently inactivate microorganisms,
- Physics and chemistry ofspark discharges is little known,
- There is no consensus over plasma formation mechanism and all the more on biocidal effects leading to sterilization,
- To fully understand which of these effects of spark discharge has the main influence on bacteria and microorganism inactivation, first we need to understand the distribution in so called electrohydraulic discharge.

Methods

- The measurements were performed on deionized water as well as on river water to determine the influence of various chemical and organic compounds present in real river water,
- The UV spectra was measured and water Andor spectrometer. The spectrometer was set to integration time of 600 ms.



DISCHARGE CHARACTERISTIC

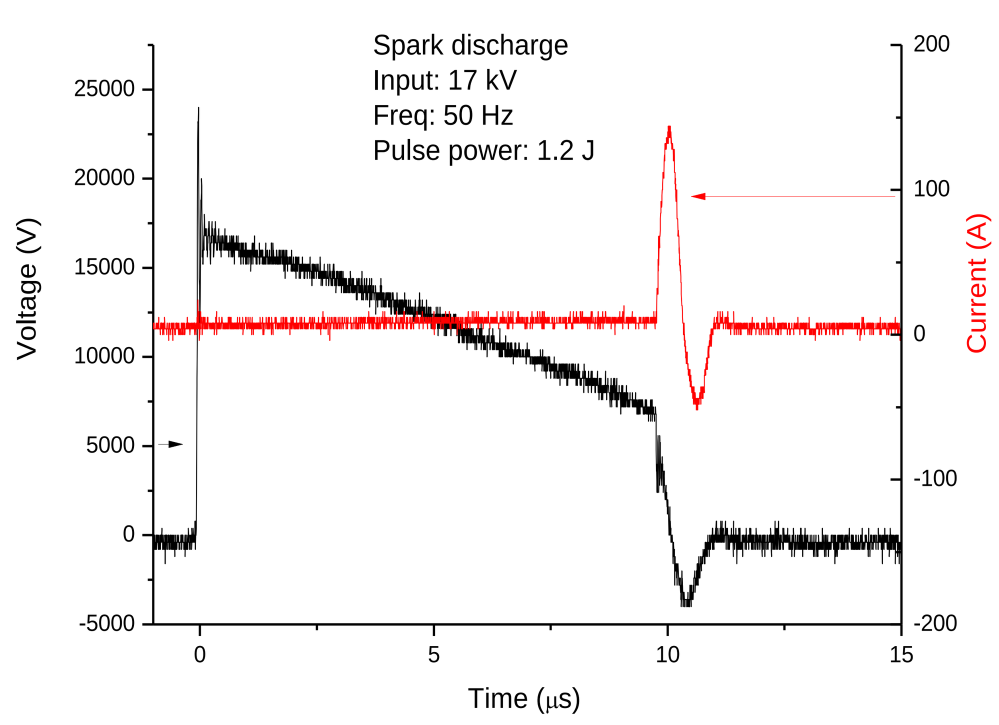
- Pulsed spark discharge,
- Applied voltage: 15-17 kV,
- Pulse repetition rate: 50 Hz,
- Avareged pulse energy: 1.4 J,
- Discharge power: 60 W.

REACTOR PARAMETERS

- Cylindrical reactor made of PTFE,
- Inner diameter: 25 mm,
- High voltage electrode -> Stainless steel hypodermic needle, inner diameter: 1.6 mm,
- Outer diameter: 2 mm,
- Grounded electrode -> Stainless stell rod, diameter: 5 mm,
- Gap between the electrodes: from 3 mm.

Input Energy

CURRENT-VOLTAGE CHARACTERISTICS



$$E_p = \int U(t)I(t)dt$$

Spark discharge power calculetad was **60 W**. This values is averaged over 100 pulses.

Thermal Energy Emissions

Thermal energy emission from plasma emission was calculated according to Jule's law:

$$Q = c \cdot m \cdot (T_k - T_p) \quad [J],$$

where:

c – specific heat of the medium,

m – mass of the medium,

Tp – initial temperature,

Tk – final temperature.

$$Q = 4187\frac{J}{kg \cdot K}0.026kg + 300\frac{J}{kg \cdot K} \cdot 0.0042kg \cdot (21.5K - 13.5K) = 1097.33J$$

Thermal Power:

Thermal power emitted during 30 s of the electrohydraulic spark discharge was **36.5 W.**

Results

Acoustic Energy Emissions

FREQUENCY DISTRIBUTION OF SOUND INTENSITY LEVELS

Frequency	Sound intensity level	Sound intensity
[Hz]	[dB]	[W/m^2]
1	25.9	3.89E-10
2	38.5	7.079E-09
4	49.8	9.55E-08
8	52.2	1.66E-07
16	51	1.259E-07
31,5	51	1.259E-07
63	48	6.31E-08
125	50.4	1.096E-07
250	48	6.31E-08
500	50.9	1.23E-07
1000	57.1	5.129E-07
2000	74.8	3.02E-05
4000	79.5	8.913E-05
8000	80.4	0.0001096
16000	78.2	6.607E-05
	Log sum=	**0.2964 mW/m^2**

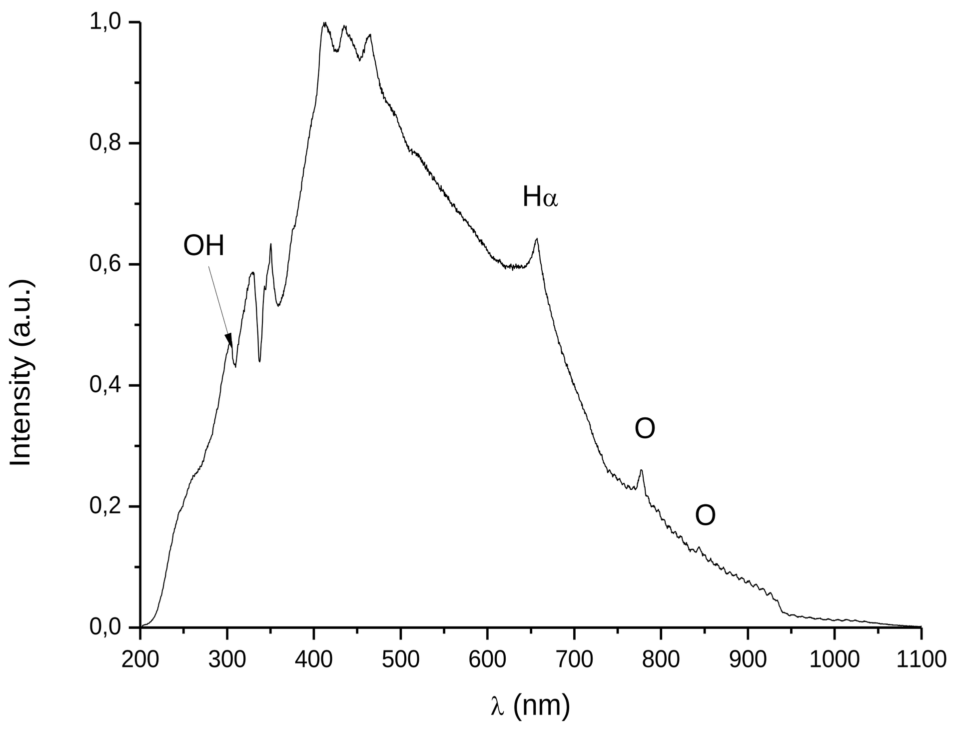
Acoustic Power measured:

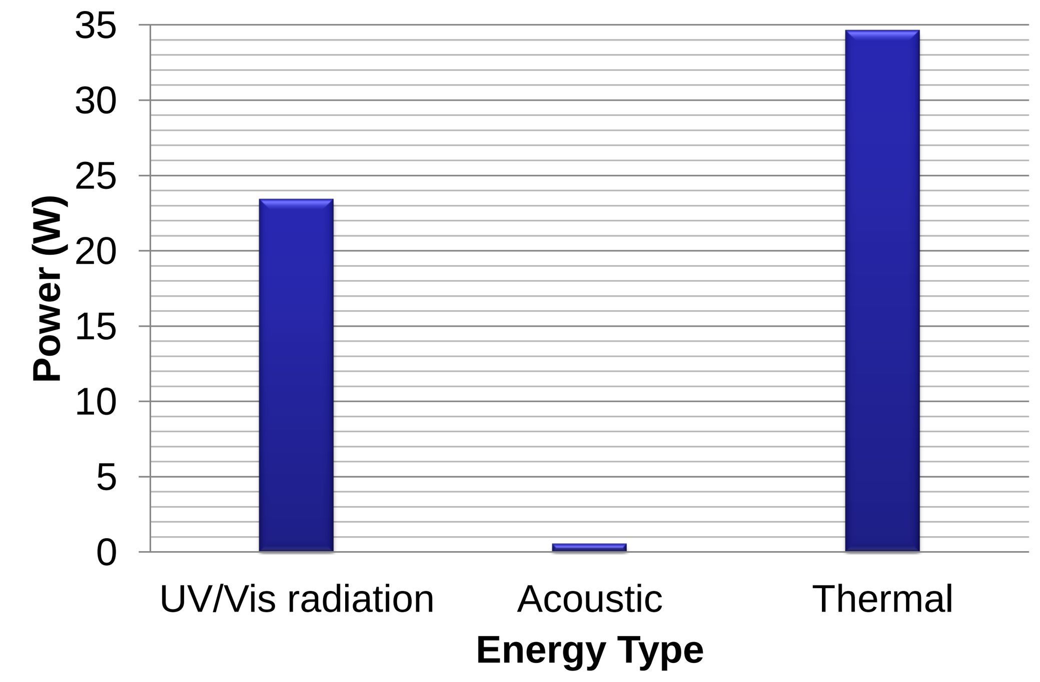
$$P = \frac{I}{e^{-mr}}4\pi r^2 = \frac{0,0002964[W/m^2]}{e^{-0,3}}4\pi \cdot 0.3[m]^2 = (0.4 \pm 0.05)mW$$

Frequency distribution of sound intensity generated by the electrohydraulic discharge reactor at a distance of 30 cm**.**

UV/Vis Spectra Emissions

UV/VIS SPECTRA OF SPARK DISCHARGE UNDER WATER





Energy distribution in electrohydraulic spark discharge

Conclusions

- Results of measurements show that 36.5 W, which is more than 50% of energy delivered to the spark discharge, is spent for water heating,
- Acoustic power emission is 0.4 mW which is comparable to loud speaking,
- Rest of the discharge power, i.e. 23.4 W, is distributed among UV/Vis radiation and chemical reactions in the reactor.

Acknowledgments

This research work was supported by the European Social Fund, the State Budget and the Pomorskie Voivodeship Budget according to the Operational Programme Human Capital, Priority VIII, Action 8.2, Under-action 8.2.2: 'Regional Innovation Strategy' within the system project of the Pomorskie Voivodeship "InnoDoktorant – Scholarships for PhD students, Vth edition" and by the National Center of Science according to decision number DEC-2011/01/N/ST8/05300