

VIZUALIZATION OF THE CAVITATING JET USING FLASHLAMP FOR ILLUMINATION

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Abstract: The contribution deals with the ways of the illumination of the cavitating jet for the purposes of the visualization. The cavitation is induced by the fluid flow through the orifice with the diameter of 0,3mm. Region of the cavitating jet is illuminated by a different light sources. Goal of this paper is to compare the quality and the informative value of the obtained visual data. In addition, complicated structure of the cavitating jet is also shown and described

1. INTRODUCTION

The knowledge of the structure and the behavior of the cavitating jet is very important for the design and the optimization of the devices working on the principle of cavitation. Cavitating jets are used in wide spectrum of the applications. For example cavitation is used for cleaning the paint and the dirt from the solid surfaces, removing of the explosives from ammunition [1], deep drilling [2]. Known are also the applications in the surgery, in cutting of the different materials or for killing the bacteria without using the chemicals. Because the cavitating jets are more and more used, the need to better understand of the behavior and structure of the cavitation raises. Commonly used criteria for description of the cavitation (like cavitation number, criteria for describing of the destructive effects) describes only the the effects on the solid surfaces. But they give no idea about the origin of these effects. For better design of the cavitating jets is important to better understand the behavior and structure of the cavitation dependent on other parameters (like cavitation number, pressures, velocity, destruction effect). For this purpose, the high-speed imagination can be used very effectively. And one of the key parameters in high-speed imagination of the cavitating jet is the illumination source (**Figure 1**).

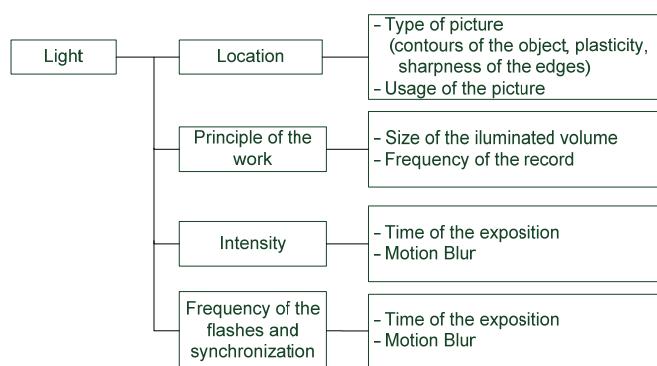


Figure 1: Function of the light in high-speed imagination

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The importance of the illumination will be demonstrated by the comparison of the pictures obtained by using different light sources. Structure and behavior of the cavitation jet will be also demonstrated by different regimes of the flow.

2. DESCRIPTION OF THE MEASURING CIRCUIT

The measuring circuit for the experiments with the cavitation consists of four main parts (**Figure 2**): hydraulic circuit, specimen, DAQ system and system used for visualization. All of the parts are synchronized by the industrial computer.

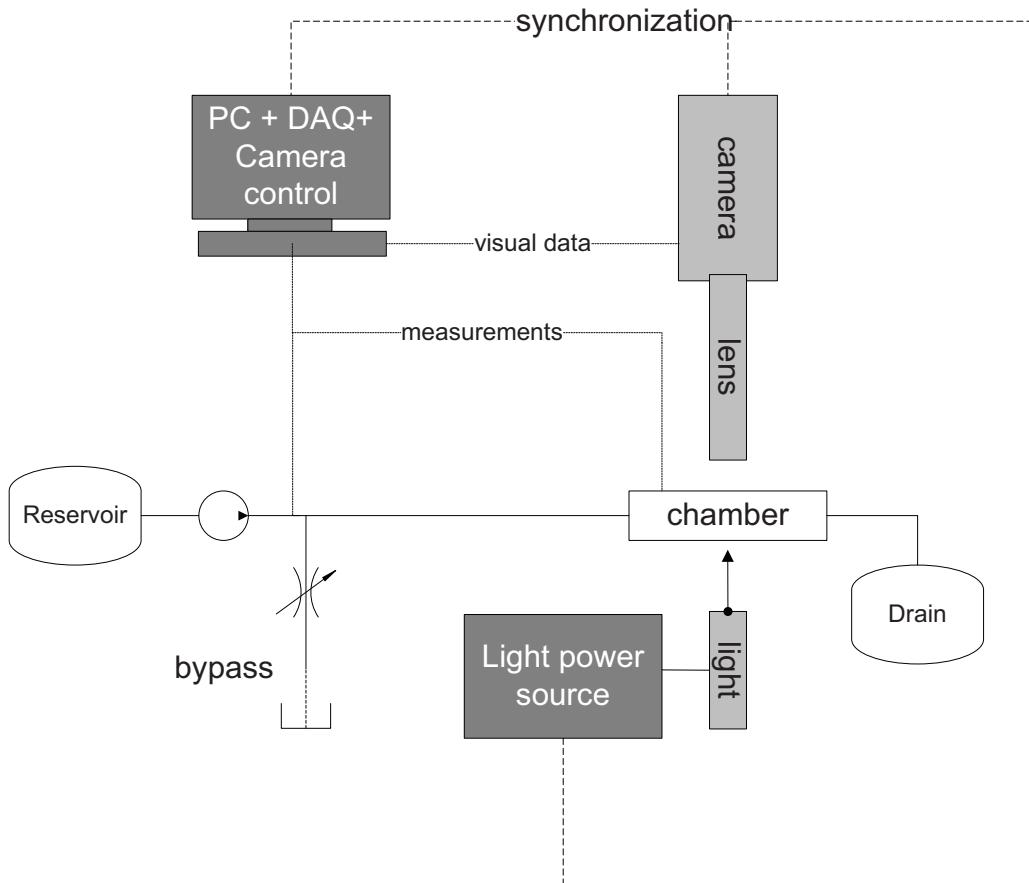


Figure 2: Scheme of the measuring circuit

Visualization part consist of the high speed camera (IDT redlake Y3), test chamber and the illumination. Optics of the camera consist from the telecentric microscopic objective and the mounting piece for the objective. Total visible area in these configuration is 3x3mm.

3. ILLUMINATION OF THE TEST CHAMBER

Continual illumination source SCHOTT KL-1500 and the pulse flashlight NANOLITE KL-L with power source MINISTROBOKIN were used for the experiments. Description of the devices is in **Tab 1** and **Tab 2**.

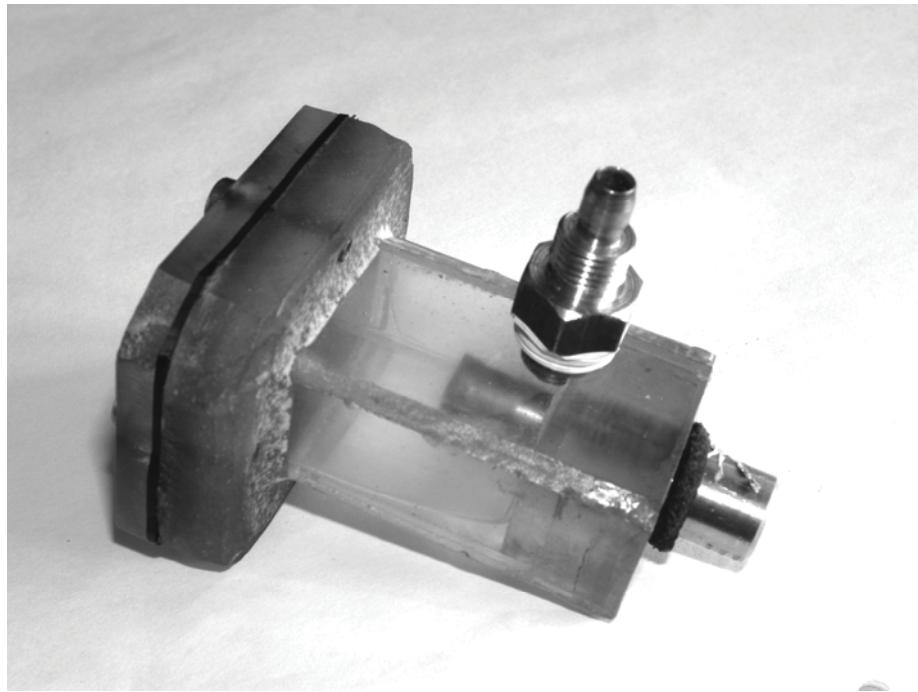


Figure 3: Test chamber

Tab 1 Properties of used flash light source

Principle of work	Electric discharge
Type of the light	White, cold
Maximum frequency	20 000 Hz
Flash duration	18 ns
Energy of the flash	25mJ
Maxminum amount of flashes by max. frequency	200
Synchronization	External or internal
Used focusing optics	no

Tab 2 Properties of used continual light source

Type of the light	White, range cold to warm
Power	150W
Synchronization	None
Used focusing optics	Optical fibre

With the flashlamp, the pictures were exposed using the shadow illumination. This type of the illumination was selected because of better visibility and sharpness of the corners of the cavitating jet. Also the tiny separated bubbles near main jet are better visible using this type of illumination. No additive optics is installed in the flashlamp, so no other directions of illumination are possible in this configuration.

Used laboratory illumination source gives continual white light with optional temperature. As focusing optics is used optical fibre. Direction of illumination can be changed.

4. OBSERVATIONS

On the **Figure 4** can be seen the cavitation jet in different regimes. The pictures were obtained using the flashlamp.

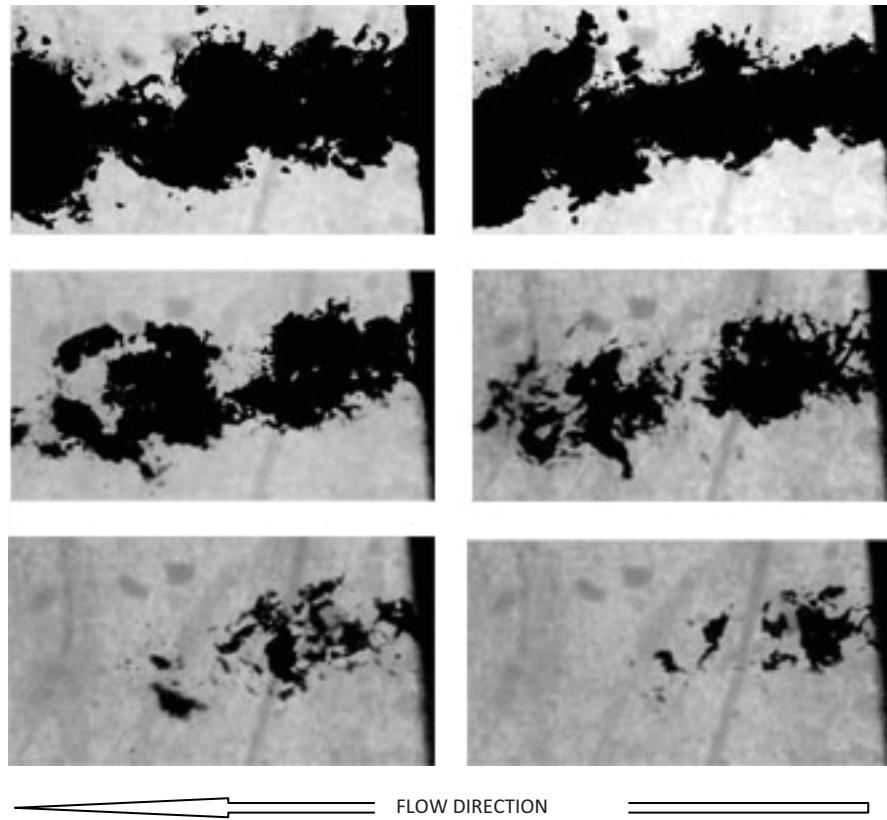


Figure 4: Structure of the cavitation cloud in flow with different cavitation number, exposure time=18 ns, ($\sigma=0.040, \sigma=0.035, \sigma=0.058, \sigma=0.066, \sigma=0.098, \sigma=0.125$)

Complicated structure of the cavitating jet can be observed on the pictures (**Figure 4**). It can be seen that even by very low cavitation numbers the jet isn't symmetric and has a very complicated shape and changes very fast. This observations are in accordance with [3],[4]. Using of the very short exposition time (18 ns) allows detailed exploration of the structure and behavior of the cavitating jet.

Pictures obtained using continual light source (**Figure 5**) also shows the structure of the jet. In this case, the exposure is 2 μ s. This is caused by low intensity of the light. A strong motion blur can be observed on this pictures, so the pictures don't have the informative value so high as pictures obtained with flashlamp.

Absolutely unsuitable is combination of the continual light and other type of the illumination as shadow illumination. As can be seen on the **Figure 6**, it is impossible to find sharp corners of the jet or find the structure. The motion blur is very strong, so the jet looks like homogenous object without any complicated structure. Only possibility to use this type of illumination is to use the more intensive light source, so shorter exposure time can be used.

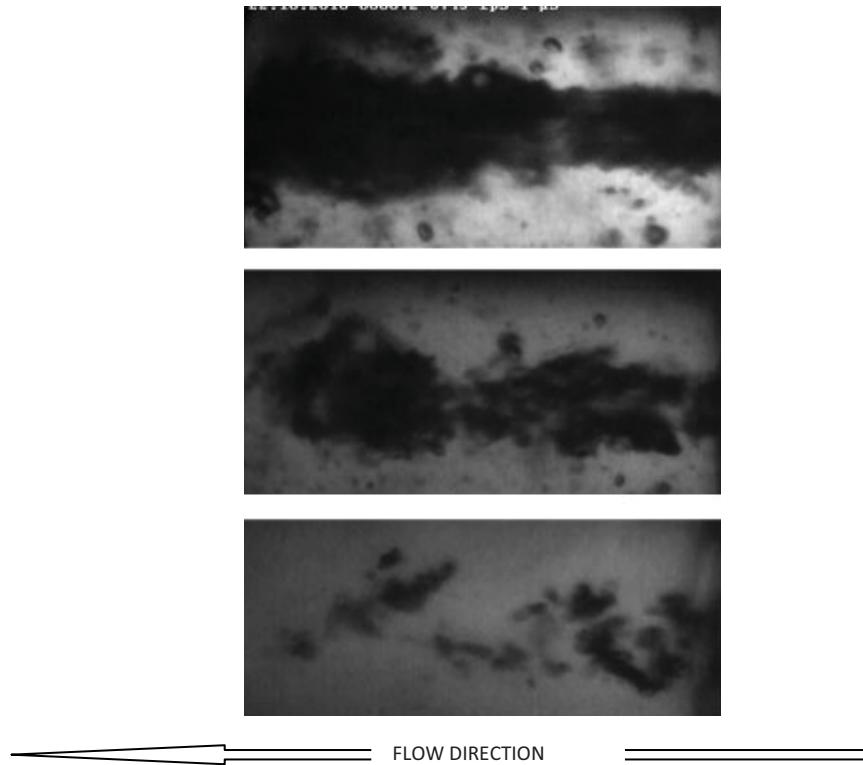


Figure 5: Structure of the cavitation cloud captured with continual light by different cavitation number, exposure time=1 μ s, ($\sigma=0.040, \sigma=0.066, \sigma=0.125$)

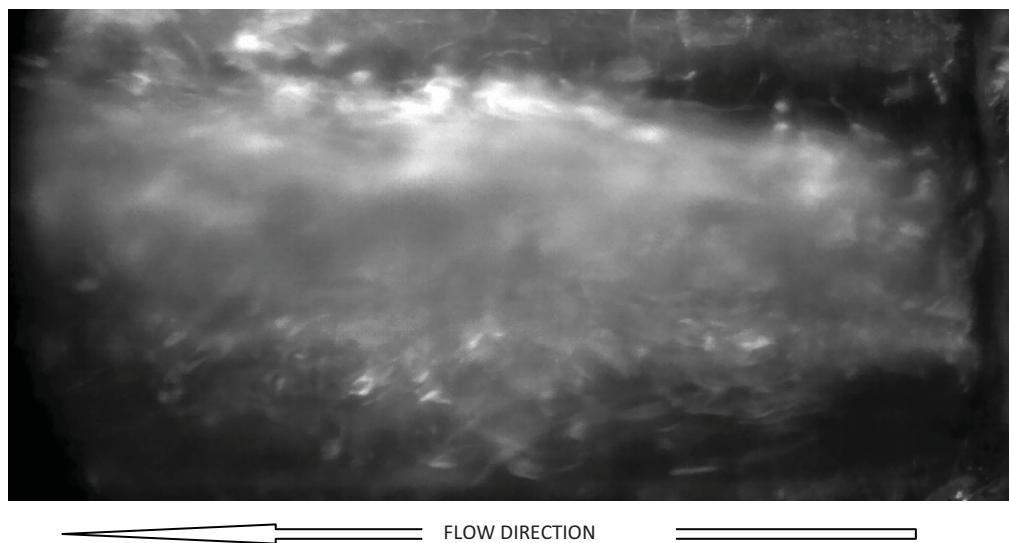


Figure 6: Structure of the cavitation cloud captured with continual light ($\sigma=0.040$), exposure time 40 μ s

5. CONCLUSION

Observing the cavitation without using the high-speed imagination and the powerful enough illumination source can give us idea that cavitation jet is homogenous, symmetric and stable area containing cavitation bubbles. High-speed camera show us that the jet is very complicated, not homogenous structure containing a lot of the substructures and it is changing very fast in time. This non-stationary behavior of the jet has strong influence on the destructive effect of the cavitation. Better understanding of this behavior is essential for next development and design of cavitation jets.

To obtain the usable visual data, with the sufficient quality for research, is essential to use powerful visualization hardware. The light is very important part of this hardware. Contribution clearly demonstrates the influence of the illumination to the quality and the informative value of the obtained visual data. Clearly, in our case, ist usage of the flashlight is best way to illuminate cavitating jet. It's caused by a very high energy of the single flashes. This allows to use very short exposition time, which is critical factor in imagination of high-speed phenomenon such as cavitation. Using of exposition time in order of nanoseconds give us way to see structure of the jet without motion blur. Even tiny separated bubbles can be seen. Tracking of these bubbles gives us only way to calculate the flowfield near the cavitating jet. It's because inserting of any other particles to the examined fluid can change the conditions of the experiment.

6. ACKNOWLEDGMENT

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7. REFERENCES

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